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SUBSTRATE PROCESSING SYSTEM, SUBSTRATE PROCESSING METHOD, AND RECORDING MEDIUM

Abstract

A substrate processing system includes a carry-in/out unit in which a cassette accommodating therein multiple substrates is carried in and out; a batch processing unit configured to process a lot including the multiple substrates at once; a single-wafer processing unit configured to process the substrates one by one; a first interface unit configured to distribute the substrates to the single-wafer processing unit or the batch processing unit; and a second interface unit configured to transfer the substrates between the batch processing unit and the single-wafer processing unit. The first interface unit includes a first placement unit configured to place therein the substrates before and after being processed by the single-wafer processing unit; a second placement unit configured to place therein the substrates before being processed by the batch processing unit; and a transfer device configured to transfer the substrates to the first placement unit and the second placement unit.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION [0001] This is a continuation application of U.S. patent application Ser. No. 18/170,087 filed on Feb. 16, 2023, which claims the benefit of Japanese Patent Application No. 2022-024981 filed on Feb. 21, 2022, the entire disclosures of which are incorporated herein by reference.

TECHNICAL FIELD
[0002] The various aspects and embodiments described herein pertain generally to a substrate processing system, a substrate processing method, and a recording medium.
BACKGROUND
[0003] A substrate processing system described in Patent Document 1 includes a batch processing unit and a single-wafer processing unit. The batch processing unit maintains semiconductor wafers washed with water in the water. The semiconductor wafers are chemically processed in the state that a plurality of the wafers is mounted on a single holder. A transfer unit picks up the semiconductor wafers one by one from a buffer tank, and transfers each of them to the single-wafer processing unit. The single-wafer processing unit dries the single semiconductor wafer transferred by the transfer unit, while supporting the semiconductor wafer so that a main surface thereof is kept horizontal.
[0004] Patent Document 1: Japanese Patent Laid-open Publication No. 2021-064654
SUMMARY
[0005] In one exemplary embodiment, a substrate processing system includes a carry-in/out unit in which a cassette accommodating therein multiple substrates is carried in and out; a batch processing unit configured to process a lot including the multiple substrates at once; a single-wafer processing unit configured to process the substrates one by one; a first interface unit configured to distribute the substrates accommodated in the cassette to either the single-wafer processing unit or the batch processing unit; and a second interface unit configured to transfer the substrates between the batch processing unit and the single-wafer processing unit. The first interface unit includes a first placement unit configured to place therein the substrates before and after being processed by the single-wafer processing unit; a second placement unit configured to place therein the substrates before being processed by the batch processing unit; and a transfer device configured to transfer the substrates accommodated in the cassette to the first placement unit and the second placement unit.
[0006] The foregoing summary is illustrative only and is not intended to be any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] In the detailed description that follows, embodiments are described as illustrations only since various changes and modifications will become apparent to those skilled in the art from the following detailed description. The use of the same reference numbers in different figures indicates similar or identical items.

[0008] FIG. **1** is a plan view illustrating a substrate processing system according to an exemplary embodiment;

[0009] FIG. **2** is a flowchart illustrating a substrate processing method according to the exemplary embodiment;

[0010] FIG. **3** is a diagram illustrating an operation of a complex processing of the substrate processing method according to the exemplary embodiment; and

[0011] FIG. **4** is a diagram illustrating an operation of a single-wafer processing of the substrate processing method according to the exemplary embodiment.

DETAILED DESCRIPTION

[0012] In the following detailed description, reference is made to the accompanying drawings, which form a part of the description. In the drawings, similar symbols typically identify similar components, unless context dictates otherwise. Furthermore, unless otherwise noted, the description of each successive drawing may reference features from one or more of the previous drawings to provide clearer context and a more substantive explanation of the current exemplary embodiment. Still, the exemplary embodiments described in the detailed description, drawings, and claims are not meant to be limiting. Other embodiments may be utilized, and other changes may be made, without departing from the spirit or scope of the subject matter presented herein. It will be readily understood that the aspects of the present disclosure, as generally described herein and illustrated in the drawings, may be arranged, substituted, combined, separated, and designed in a wide variety of different configurations, all of which are explicitly contemplated herein.

[0013] Hereinafter, non-limiting exemplary embodiments of the present disclosure will be described with reference to the accompanying drawings. In all of the accompanying drawings, same or corresponding parts or components will be assigned same reference numerals, and redundant description thereof will be omitted.

Substrate Processing System

[0014] Referring to FIG. **1**, a substrate processing system according to an exemplary embodiment will be explained. As depicted in FIG. **1**, a substrate processing system **1** includes a carry-in/out unit **2**, a first interface unit **3**, a batch processing unit **4**, a second interface unit **5**, a single-wafer processing unit **6**, and a control device **9**.

[0015] The carry-in/out unit **2** serves as both a carry-in unit and a carry-out unit. For this reason, the substrate processing system **1** can be reduced in size. The carry-in/out unit **2** includes a load port **21**, a stocker **22**, a loader **23**, and a cassette transfer device **24**.

[0016] The load port **21** is disposed on the negative X-axis side of the carry-in/out unit **2**. The load port **21** is plural in number, and the plurality of (for example, four) load ports **21** are arranged along the Y-axis direction. However, the number of the load ports **21** is not particularly limited. A cassette C is placed in each load port **21**. The cassette C accommodates therein a plurality of (for example, 25) substrates W, and is carried into/from the load port **21**. Inside the cassette C, the substrates W are held horizontally at a second pitch P**2** therebetween in a vertical direction. The second pitch is N times a first pitch P**1** (P**2**=N×P**1**). N is a natural number equal to or larger than 2. In the present exemplary embodiment, N is 2. However, it may be 3 or more.

[0017] The stocker **22** is plural in number, and the plurality of (for example, four) stockers **22** are arranged along the Y-axis direction at the center of the carry-in/out unit **2** in the X-axis direction. A plurality of (for example, two) stockers **22** are disposed along the Y-axis direction to be adjacent to a first interface unit **3** on the positive X-axis side of the carry-in/out unit **2**. The stockers **22** may be arranged in multiple levels in a vertical direction. The stocker **22** temporarily stores therein a cassette C in which substrates W before being subjected to a cleaning processing are stored, an empty cassette C from which substrates W have been taken out, and so forth. Here, the number of the stockers **22** is not particularly limited.

[0018] The loader **23** is provided adjacent to the first interface unit **3**, and is disposed on the positive X-axis side of the carry-in/out unit **2**. The cassette C is placed in the loader **23**. The loader **23** is provided with a lid opening/closing mechanism (not shown) for opening or closing a lid of the cassette C. The loader **23** may be plural in number, and the plurality of loaders **23** may be arranged in multiple levels in the vertical direction.

[0019] The cassette transfer device **24** is, for example, a multi-joint transfer robot. The cassette transfer device **24** transfers the cassette C between the load port **21**, the stocker **22**, and the loader **23**.

[0020] The first interface unit **3** is disposed on the positive X-axis side of the carry-in/out unit **2**. The first interface unit **3** transfers the substrate W between the carry-in/out unit **2**, the batch processing unit **4**, and the single-wafer processing unit **6**. The first interface unit **3** has a substrate moving/placing device **31**, a lot forming unit **32**, and a first delivery table **33**.

[0021] The substrate moving/placing device **31** transfers the substrate W between the cassette C disposed in the loader **23**, the lot forming unit **32**, and the first delivery table **33**. The substrate moving/placing device **31** distributes the substrates W accommodated in the cassette C placed in the loader **23** to the first delivery table **33** for transferring the substrates to the single-wafer processing unit **6** and the lot forming unit **32** for transferring the substrates to the batch processing unit **4**. The substrate moving/placing device **31** is composed of a multi-axis (for example, 6-axis) arm robot, and has a substrate holding arm **31***a* at a leading end thereof. The substrate holding arm **31***a* has a plurality of holding claws (not shown) capable of holding a plurality of (for example, 25 sheets) substrates W. The substrate holding arm **31***a* can take any position and posture in a three-dimensional space while holding the substrates W with the holding claws.

[0022] The lot forming unit **32** is disposed on the positive X-axis side of the first interface unit **3**. The lot forming unit **32** holds a plurality of substrates W at the first pitch P**1** to form a lot L.

[0023] The first delivery table **33** is disposed adjacent to the single-wafer processing unit **6** on the positive Y-axis side of the first interface unit **3**. The first delivery table **33** includes a first region in which the substrate W before being processed in the single-wafer processing unit **6** is placed and a second region in which the substrate W after being processed in the single-wafer processing unit **6** is placed. The first region and the second region are arranged in the vertical direction. Desirably, the second region is provided at an upper end in the vertical direction than the first region. In this case, it is possible to suppress the substrate after being processed from being contaminated with a foreign substance falling from the substrate before being processed. In the first region, a plurality of substrates W is disposed at the second pitch P**2** therebetween. The first region is configured to place therein a first number of sheets of substrates W. The first number of sheets is, for example, 25 sheets. The first number is, for example, the same number as the number of substrates W accommodated in the cassette C. In the second region, a multiplicity of substrates W are disposed at the second pitch P**2** therebetween. The second region is configured to place therein a second number of sheets of substrates W. The second number of sheets is larger than the first number of sheets, and is, for example, 50 sheets or 100 sheets. The second number is, for example, the same number as the number of substrates W constituting the lot L. The lot L is composed of the substrates W carried from the multiple cassettes C. In the first region, the first delivery table **33** receives the substrate W from the substrate moving/placing device **31** and temporarily stores the received substrate W therein until the substrate W is transferred to the single-wafer processing unit **6**. In the second region, the first delivery table **33** receives the substrate W from a fourth transfer device **61** and temporarily stores the received substrate W therein until the substrate W is handed over to the carry-in/out unit **2**.

[0024] The batch processing unit **4** is disposed on the positive X-axis side of the first interface unit **3**. That is, the carry-in/out unit **2**, the first interface unit **3**, and the batch processing unit **4** are disposed in this order from the negative X-axis side toward the positive X-axis side. The batch processing unit processes the lot L incorporating therein a multiple number of sheets (for example, 50 sheets or 100 sheets) of substrates W at the first pitch P**1**. The single lot L is composed of substrates W from, for example, M number of cassettes. M is a natural number equal to or larger than **2**. M may be the same natural number as N, or may be a natural number different from N. The batch processing unit **4** includes a chemical liquid tank **41**, a rinse liquid tank **42**, a first transfer device **43**, a processing tool **44**, and a driving device **45**.

[0025] The chemical liquid tank **41** and the rinse liquid tank **42** are disposed along the X-axis direction. By way of example, the chemical liquid tank **41** and the rinse liquid tank **42** are arranged in this order from the positive X-axis side toward the negative X-axis side. Further, the chemical liquid tank **41** and the rinse liquid tank **42** are referred to as a processing tank together. The number of the chemical liquid tank **41** and the rinse liquid tank **42** is not limited to the example shown in FIG. **1**. For example, although a single set of the chemical liquid tank **41** and the rinse liquid tank **42** is provided in FIG. **1**, multiple sets may be provided.

[0026] The chemical liquid tank **41** stores therein a chemical liquid in which the lot L is to be immersed. The chemical liquid is, for example, a phosphoric acid aqueous solution (H.sub.3PO.sub.4). The phosphoric acid aqueous solution selectively etches and removes a silicon nitride film among a silicon oxide film and the silicon nitride film. The chemical liquid is not limited to the phosphoric acid aqueous solution. By way of example, the chemical liquid may be DHF (dilute hydrofluoric acid), BHF (a mixed solution of hydrofluoric acid and ammonium fluoride), dilute sulfuric acid, SPM (a mixed solution of sulfuric acid, hydrogen peroxide and water), SC1 (a mixed solution of ammonia, hydrogen peroxide and water), SC2 (a mixed solution of hydrochloric acid, hydrogen peroxide and water), TMAH (a mixed solution of tetramethylammonium hydroxide and water), a plating solution, or the like. The chemical liquid may be used for a peeling processing or a plating processing. The number of the chemical liquid is not particularly limited, and a plurality of chemical liquids may be used.

[0027] The rinse liquid tank **42** stores therein a first rinse liquid in which the lot Lis to be immersed. The first rinse liquid is, for example, DIW (deionized water) as pure water that removes the chemical liquid from the substrate W.

[0028] The first transfer device **43** has a guide rail **43***a* and a first transfer arm **43***b*. The guide rail **43***a* is disposed on the negative Y-axis side of the processing tank. The guide rail **43***a* extends from the first interface unit **3** to the batch processing unit **4** along a horizontal direction (X-axis direction). The first transfer arm **43***b* is moved in the horizontal direction (X-axis direction) along the guide rail **43***a*. The first transfer arm **43***b* may be moved in a vertical direction or may be rotated around a vertical axis. The first transfer ram **43***b* transfers the lot L collectively between the first interface unit **3** and the batch processing unit **4**.

[0029] The processing tool **44** receives the lot L from the first transfer arm **43***b* and holds it. The processing tool **44** holds the multiple number of substrates W at the first pitch P**1** in the Y-axis direction, while holding each of the multiple number of substrates W vertically.

[0030] The driving device **45** moves the processing tool **44** in the X-axis direction and the Z-axis direction. The processing tool **44** immerses the lot L in the chemical liquid stored in the chemical liquid tank **41**, then immerses the lot L in the first rinse liquid stored in the rinse liquid tank **42**, and, thereafter, hands the lot L over to the first transfer device **43**.

[0031] The unit number of the processing tool **44** and the driving device **45** is one in the present exemplary embodiment. However, they may be plural. In the latter case, one unit may immerse the lot L in the chemical liquid stored in the chemical liquid tank **41**, and the other unit may immerse the lot L in the first rinse liquid stored in the rinse liquid tank **42**. In this case, the driving device **45** only needs to move the processing tool **44** in the Z-axis direction, and may not need to move the processing tool **44** in the X-axis direction.

[0032] The second interface unit **5** is disposed on the positive Y-axis side of the batch processing unit **4**. The second interface unit **5** transfers the substrate W between the batch processing unit **4** and the single-wafer processing unit **6**. The second interface unit **5** has an immersion tank **51**, a second transfer device **52**, a third transfer device **53**, and a second delivery table **54**.

[0033] The immersion tank **51** is disposed outside a movement range of the first transfer arm **43***b*. For example, the immersion tank **51** is disposed at a position shifted from the processing tank in the positive Y-axis direction. The immersion tank **51** stores therein a second rinse liquid in which the lot L is to be immersed. The second rinse liquid is, for example, DIW (deionized water). The substrate W is maintained in the second rinse liquid until it is picked up from the second rinse liquid by the third transfer device **53**. Since the substrate W exists below a liquid surface of the second rinse liquid, a surface tension of the second rinse liquid does not act on the substrate W, so that a collapse of an irregularity pattern of the substrate W can be suppressed.

[0034] The second transfer device **52** includes a Y-axis driving device **52***a*, a Z-axis driving device **52***b*, and a second transfer arm **52***c*.

[0035] The Y-axis driving device **52***a* is disposed on the positive X-axis side of the second interface unit **5**. The Y-axis driving device **52***a* extends from the second interface unit **5** to the batch processing unit **4** along a horizontal direction (Y-axis direction). The Y- axis driving device **52***a* moves the Z-axis driving device **52***b* and the second transfer arm **52***c* in the Y-axis direction. The Y-axis driving device **52***a* may include a ball screw.

[0036] The Z-axis driving device **52***b* is movably mounted to the Y-axis driving device **52***a*. The Z-axis driving device **52***b* moves the second transfer arm **52***c* in the Z-axis direction. The Z-axis driving device **52***b* may include a ball screw.

[0037] The second transfer arm **52***c* is movably mounted to the Z-axis driving device **52***b*. The second transfer arm **52***c* receives the lot L from the first transfer arm **43***b* and holds it. The second transfer arm **52***c* holds the multiple number of substrates W at the first pitch P**1** in the Y-axis direction, while holding each of the substrates W vertically. The second transfer arm **52***c* is moved in the Y-axis direction and the Z-axis direction by the Y-axis driving device **52***a* and the Z-axis driving device **52***b*. The second transfer arm **52***c* is configured to be movable between multiple positions including a delivery position, an immersion position, and a standby position.

[0038] The delivery position is a position where the lot L is delivered between the first transfer arm **43***b* and the second transfer arm **52***c*. The delivery position is a position on the negative Y-axis and positive Z-axis side.

[0039] The immersion position is a position where the lot L is immersed in the immersion tank **51**. The immersion position is a position on the positive Y-axis and negative Z-axis side of the delivery position.

[0040] The standby position is a position where the second transfer arm **52***c* stands by when the lot L is neither transferred nor immersed in the immersion tank **51**. The standby position is a position located directly below the delivery position (negative Z-axis side) without hindering a movement of the first transfer arm **43***b*. In this case, since the second transfer arm **52***c* can be moved to the delivery position only by moving upwards (in the positive Z-axis direction), a throughput is improved. The standby position may be the same position as the immersion position. In this case, particles that may be generated as a result of the operation of the first transfer device **43** can be suppressed from adhering to the second transfer arm **52***c*. Alternatively, the standby position may be a position directly above the immersion position (positive Z-axis side). In this way, by setting the standby position to be different from the transfer position, a contact between the first transfer arm **43***b* and the second transfer arm **52***c* can be suppressed.

[0041] This second transfer device **52** moves the second transfer arm **52***c* to the immersion position or the standby position while the first transfer device **43** is operating. Therefore, a contact between the first transfer arm **43***b* and the second transfer arm **52***c* can be suppressed.

[0042] The third transfer device **53** is composed of a multi-axis (for example, 6-axis) arm robot, and has a third transfer arm **53***a* at a leading end thereof. The third transfer arm **53***a* has a holding claw (not shown) capable of holding a single sheet of substrate W. The third transfer arm **53***a* can take any position and posture in a three-dimensional space while holding the substrate W with the holding claw. The third transfer device **53** transfers the substrate W between the second transfer arm **52***c* at the immersion position and the second delivery table **54**. At this time, since the immersion tank **51** is disposed outside the movement range of the first transfer arm **43***b*, the first transfer arm **43***b* and the third transfer arm **53***a* do not interfere with each other. Thus, one of the first transfer device **43** and the third transfer device **53** can be independently operated irrespective of an operational status of the other. For this reason, since the first transfer device **43** and the third transfer device **53** can be operated at required timings, the time required for the transfer of the substrate W can be shortened. As a result, productivity of the substrate processing system **1** is improved.

[0043] The second delivery table **54** is disposed adjacent to the single-wafer processing unit **6** on the negative X-axis side of the second interface unit **5**. The second delivery table **54** receives the substrate W from the third transfer device **53** and temporarily stores it until it is transferred to the single-wafer processing unit **6**. That is, the substrate W taken out from the immersion tank **51** is placed on the second delivery table **54**. It is desirable that a surface of the substrate W disposed on the second delivery table **54** is wet with, for example, the second rinse liquid. In this case, since the surface tension of the second rinse liquid does not act on the substrate W, a collapse of the irregularity pattern of the substrate W can be suppressed. A plurality of (for example, two) substrates W are placed on the second delivery table **54**.

[0044] The single-wafer processing unit **6** is disposed on the negative X-axis side of the second interface unit **5** and on the positive Y-axis side of the carry-in/out unit **2**, the first interface unit **3**, and the batch processing unit **4**. The single-wafer processing unit **6** processes the substrates W one by one. The single-wafer processing unit **6** has a fourth transfer device **61**, a liquid processing apparatus **62**, and a drying apparatus **63**.

[0045] The fourth transfer device **61** has a guide rail **61***a* and the fourth transfer arm **61***b*. The guide rail **61***a* is disposed on the negative Y-axis side of the single-wafer processing unit **6**. The guide rail **61***a* extends along a horizontal direction (X-axis direction) in the single-wafer processing unit **6**. The fourth transfer arm **61***b* is moved in the horizontal direction (X-axis direction) along the guide rail **61***a* and in the vertical direction, and is rotated around a vertical axis. The fourth transfer arm **61***b* transfers the substrate W between the second delivery table **54**, the liquid processing apparatus **62**, the drying apparatus **63**, and the first delivery table **33**. The number of the fourth transfer arm **61***b* may be one or more. In the latter case, the fourth transfer device **61** transfers a plurality of (for example, five) substrates W at once.

[0046] The liquid processing apparatus **62** is disposed on the positive X-axis and positive Y-axis side of the single-wafer processing unit **6**. The liquid processing apparatus **62** is of a single-wafer type, and it processes the substrates W one by one with a processing liquid. The liquid processing apparatus **62** is plural in number, and these liquid processing apparatuses **62** are arranged in multiple levels (e.g., three levels) in a vertical direction (Z-axis direction). Accordingly, multiple substrates W can be simultaneously processed with the processing liquid. The processing liquid may be plural in number. For example, pure water such as DIW and a drying liquid having a lower surface tension than the pure water may be used. The drying liquid may be, by way of example, alcohol such as IPA (isopropyl alcohol).

[0047] The drying apparatus **63** is disposed adjacent to the negative X-axis side of the liquid processing apparatus **62**. In this case, an end face of the single-wafer processing unit **6** on the positive Y-axis side may be disposed so as to be aligned with or substantially aligned with an end face of the second interface unit **5** on the positive Y-axis side. Therefore, since a dead space is hardly formed, a footprint of the substrate processing system **1** can be made small. In contrast, if the drying apparatus **63** is disposed adjacent to the positive Y-axis side of the liquid processing apparatus **62**, the end face of the single-wafer processing unit **6** on the positive Y-axis side may be protruded more than the end face of the second interface unit **5** on the positive Y-axis side, resulting in formation of a dead space. The drying apparatus **63** is of a single-wafer type, and it dries the substrates W one by one with a supercritical fluid. The drying apparatus **63** is plural in number, and these drying apparatuses **63** are arranged in multiple levels (e.g., three levels) in the vertical direction. Accordingly, multiple substrates W can be simultaneously dried.

[0048] Both the liquid processing apparatus **62** and the drying apparatus **63** may not be of a single-wafer type, and the liquid processing apparatus **62** may be of a single-wafer type and the drying apparatus **63** may be of a batch type. The drying apparatus **63** may dry multiple substrates W at once by using a supercritical fluid. The number of the substrates W processed at once in the drying apparatus **63** may be equal to or larger than the number of the substrates W processed at once in the liquid processing apparatus **62**, or may be less than that. Apparatuses other than the liquid processing apparatus **62** and the drying apparatus **63** may be disposed in the single-wafer processing unit **6**.

[0049] The control device **9** is, for example, a computer, and includes a CPU (Central Processing Unit) **91** and a recording medium **92** such as a memory. The recording medium **92** stores therein a program for controlling various processings performed in the substrate processing system **1**. The control device **9** controls an operation of the substrate processing system **1** by causing the CPU **91** to execute the program stored in the recording medium **92**. The control device **9** is equipped with an input interface **93** and an output interface **94**. The control device **9** receives a signal from the outside through the input interface **93** and transmits a signal to the outside through the output interface **94**.

[0050] The program is stored, for example, in a computer-readable recording medium, and is installed from the recording medium to the recording medium **92** of the control device **9**. The computer-readable recording medium may be, by way of non-limiting example, a hard disk (HD), a flexible disk (FD), a compact disk (CD), a magnet optical disk (MO), a memory card, or the like. Further, the program may be downloaded from a server through the Internet and installed in the recording medium **92** of the control device **9**.

[0051] The control device **9** is configured to control the substrate moving/placing device **31** to transfer the plurality of substrates W accommodated in the cassette C to either one of the first delivery table **33** and the lot forming unit **32** based on information associated with the cassette C carried into the carry-in/out unit **2**. The information may include a substrate type. For example, when the substrate type is a product substrate, the control device **9** controls the substrate moving/placing device **31** to transfer the substrates W accommodated in the cassettes C to the lot forming unit **32**. For another example, when the substrate type is a dummy substrate, the control device **9** controls the substrate moving/placing device **31** to transfer the substrate W accommodated in the cassette C to the first delivery table **33**.

[0052] The substrate processing system according to the exemplary embodiment described above includes the carry-in/out unit **2**, the first interface unit **3**, the batch processing unit **4**, the second interface unit **5**, and the single-wafer processing unit **6**. The first interface unit **3** is configured to distribute the substrates W accommodated in the cassette C in the carry-in/out unit **2** to either one of the single-wafer processing unit **6** and the batch processing unit **4**. The substrates W distributed to the single-wafer processing unit **6** are subjected to a single-wafer processing in the single-wafer processing unit **6**. The substrates W distributed to the batch processing unit **4** are subjected to a batch processing in the batch processing unit **4**. The second interface unit **5** transfers the batch-processed substrates W to the single-wafer processing unit **6**. The substrates W transferred to the single-wafer processing unit **6** are subjected to the single-wafer processing in the single-wafer processing unit **6**. In this way, a complex processing including the batch processing and the single-wafer processing, and the single-wafer processing without passing through the batch processing unit **4** can be performed in parallel for the substrates W accommodated in the cassettes C in the carry-in/out unit **2**.

Operation of Substrate Processing System

[0053] The operation of the substrate processing system **1** according to the exemplary embodiment, that is, a substrate processing method will be described with reference to FIG. **2** to FIG. **4**. A processing shown in FIG. **2** is carried out under the control of the control device **9**.

[0054] First, the cassette C accommodating therein the plurality of substrates W is carried into the carry-in/out unit **2**, and is placed in the load port **21**. Inside the cassette C, the substrates W are held horizontally at the second pitch P**2** therebetween in the vertical direction (P**2**=N×P**1**). N is a natural number equal to or larger than 2. Although N is 2 in the present exemplary embodiment, it may be 3 or more.

[0055] Next, the cassette transfer device **24** transfers the cassette C from the load port **21** to the loader **23** (as indicated by an arrow F**1** in FIG. **3** and an arrow G**1** in FIG. **4**). If the cassette C is transferred to the loader **23**, the lid of the cassette C is opened by the lid opening/closing mechanism.

[0056] Then, the control device **9** controls the individual components of the substrate processing system **1** so as to perform the processing shown in FIG. **2**. The control device **9** controls the individual components of the substrate processing system **1** to perform the processing shown in FIG. **2** whenever the cassette C is placed in the loader **23**.

[0057] First, if the cassette C is transferred to the loader **23**, the control device **9**, based on the information associated with the cassette C, determines whether to perform the complex processing or the single-wafer processing on the plurality of substrates W accommodated in the cassette C (S**101** in FIG. **2**).

[0058] When it is determined in the process S**101** of FIG. **2** that the complex processing is to be performed, the control device **9** controls the individual components of the substrate processing system **1** so that the substrates W accommodated in the cassettes

[0059] C are transferred to the batch processing unit **4** (S**102** in FIG. **2**). Specifically, the substrate moving/placing device **31** receives the substrates W accommodated in the cassettes C, and transfers them to the lot forming unit **32** (as indicated by an arrow F**2** in FIG. **3**). Thereafter, the lot forming unit **32** forms the lot L by holding the multiple number of substrates W at the first pitch P**1** (P**1**=P**2**/N). The single lot L is composed of the substrates W from, for example, the M number of cassettes C. Since the pitch of the substrates W is narrowed from the second pitch P**2** to the first pitch P**1**, the number of substrates W processed at once can be increased. Then, the first transfer device **43** receives the lot L from the lot forming unit **32**, and transfers it to the processing tool **44** (as indicated by an arrow F**3** in FIG. **3**).

[0060] Subsequently, the processing tool **44** is lowered from above the chemical liquid tank **41**, immerses the lot L in the chemical liquid, and performs a chemical liquid processing (S**103** in FIG. **2**). Thereafter, the processing tool **44** is raised to pick up the lot L from the chemical liquid, and then is moved in a horizontal direction (negative X-axis direction) toward a space above the rinse liquid tank **42** (as indicated by an arrow F**4** in FIG. **3**).

[0061] Next, the processing tool **44** is lowered from above the rinse liquid tank **42**, immerses the lot L in the first rinse liquid, and performs a rinse liquid processing (S**103** in FIG. **2**). Thereafter, the processing tool **44** is raised to lift up the lot L from the first rinse liquid. Subsequently, the first transfer device **43** receives the lot L from the processing tool **44**, and transfers it to the second transfer device **52**.

[0062] Then, the second transfer arm **52***c* of the second transfer device **52** is moved in a horizontal direction (positive Y-axis direction), and is lowered from above the immersion tank **51** to immerse the lot L in the second rinse liquid (S**104** in FIG. **2**, as indicate by an arrow F**5** in FIG. **3**). The plurality of substrates W of the lot L are maintained in the second rinse liquid until they are picked up from the second rinse liquid by the third transfer device **53**. Since the substrate W exists below the liquid surface of the second rinse liquid, the surface tension of the second rinse liquid does not act on the substrate W, so that a collapse of the irregularity pattern of the substrate W can be suppressed.

[0063] Next, the third transfer device **53** transfers the substrates W of the lot L held by the second transfer arm **52***c* in the second rinse liquid to the second delivery table **54** (as indicated by an arrow F**6** in FIG. **3**). The third transfer device **53** transfers the substrates W to the second delivery table **54** one by one.

[0064] Thereafter, the fourth transfer device **61** receives the substrates W from the second delivery table **54**, and transfers them to the liquid processing apparatus **62** (arrow F**7** in FIG. **3**)

[0065] Then, the liquid processing apparatus **62** processes the substrates W one by one with a liquid (S**105** in FIG. **2**). The liquid may be plural in number. By way of example, pure water such as DIW and a drying liquid having a lower surface tension than the pure water may be used. The drying liquid may be, by way of non-limiting example, alcohol such as IPA. The liquid processing apparatus **62** supplies the pure water and the drying liquid to a top surface of the substrate W in this order to form a liquid film of the drying liquid.

[0066] Subsequently, the fourth transfer device **61** receives the substrates W from the liquid processing apparatus **62**, and holds the substrate W horizontally with the liquid film of the drying liquid facing upwards. The fourth transfer device **61** transfers the substrates W from the liquid processing apparatus **62** to the drying apparatus **63** (as indicated by an arrow F**8** in FIG. **3**).

[0067] Thereafter, the drying apparatus **63** dries the substrates W one by one with a supercritical fluid (S**105** in FIG. **2**). The drying liquid can be replaced with the supercritical fluid, so that a collapse of the irregularity pattern of the substrate W due to the surface tension of the drying liquid can be suppressed. Since the supercritical fluid requires a pressure-resistant vessel, the drying processing is performed as a single-wafer processing instead of a batch processing in order to size down the pressure-resistant vessel.

[0068] In addition, although the drying apparatus **63** is of the single-wafer type in the present exemplary embodiment, it may be of a batch type as mentioned above. The batch-type drying apparatus **63** dries the plurality of substrates W having the liquid film at once with the supercritical fluid. While the single-wafer type drying apparatus **63** has one transfer arm for holding the substrate W, the batch type drying apparatus **63** has a plurality of transfer arms.

[0069] Further, although the drying apparatus **63** of the present exemplary embodiment dries the substrate W with the supercritical fluid, a drying method is not particularly limited. The drying method may be any of various methods as long as the collapse of the irregularity pattern of the substrate W can be suppressed. By way of example, spin drying, scan drying, or water repellent drying may be adopted. In the spin drying, the substrate W is rotated and the liquid film is scattered from the substrate W by a centrifugal force. In the scan drying, by rotating the substrate W while moving a supply position of the drying liquid from a center of the substrate W toward a periphery of the substrate W, the liquid film is scattered form the substrate by a centrifugal force. In the scan drying, a supply position of a drying gas such as a N.sub.2 gas may be moved from the center of the substrate W toward the periphery thereof so as to follow the supply position of the drying liquid.

[0070] Subsequently, the fourth transfer device **61** receives the substrates W from the drying apparatus **63**, and transfers them to the first delivery table **33** (as indicated by an arrow F**9** in FIG. **3**).

[0071] Next, the substrate moving/placing device **31** receives the substrate W from the first delivery table **33** and stores it in the cassette C disposed on the loader **23** (S**106** in FIG. **2**, as indicated by an arrow F**10** in FIG. **3**).

[0072] Next, the cassette transfer device **24** transfers the cassette C from the loader **23** to the load port **21** (as indicated by an arrow F**11** in FIG. **3**). The cassette C transferred to the load port **21** is carried out from the carry-in/out unit **2** while accommodating the multiple number of substrates W therein. Here, the cassette transfer device **24** may transfer the cassette C from the loader **23** to the stocker **22** and store it temporarily in the stocker **22**.

[0073] When it is determined in the process S**101** of FIG. **2** that the batch processing is to be performed, the control device **9** controls the individual components of the substrate processing system **1** to move the substrates W accommodated in the cassette C to the single-wafer processing unit **6** (S**107** in FIG. **2**). Specifically, the substrate moving/placing device **31** receives the substrates W accommodated in the cassette C, and transfers them to the first delivery table **33** (as indicate by an arrow G**2** in FIG. **4**). Subsequently, the fourth transfer device **61** receives the substrates W from the first delivery table **33**, and transfers them to the liquid processing apparatus **62** (as indicated by an arrow G**3** in FIG. **4**).

[0074] Next, the same as in the process S**105** in FIG. **2**, the liquid processing apparatus **62** processes the substrates W one by one with the liquid, and, then, the drying apparatus **63** dries the substrates W one by one with the supercritical fluid (S**108** in FIG. **2**, as indicated by an arrow G**4** in FIG. **4**).

[0075] Thereafter, the fourth transfer device **61** receives the substrates W from the drying apparatus **63**, and transfers them to the first delivery table **33** (as indicated by an arrow G**5** in FIG. **4**).

[0076] Afterwards, the substrate moving/placing device **31** receives the substrate W from the first delivery table **33** and stores them in the cassette C placed in the loader **23** (S**109** in FIG. **2**, as indicated by an arrow G**6** in FIG. **4**).

[0077] Then, the cassette transfer device **24** transfers the cassette C from the loader **23** to the load port **21** (as indicated by an arrow G**7** in FIG. **4**). The cassette C transferred to the load port **21** is carried out from the carry-in/out unit **2** while accommodating therein the multiple number of substrates W. Further, the cassette transfer device **24** may transfer the cassette C from the loader **23** to the stocker **22** and store it temporarily in the stocker **22**.

[0078] In the substrate processing method according to the above-described exemplary embodiment, if, for example, a first cassette to be subjected to the complex processing is transferred to the loader **23**, the first interface unit **3** distributes substrates W accommodated in the first cassette to the batch processing unit **4**.

[0079] The substrates W distributed to the batch processing unit **4** are subjected to the batch processing in the batch processing unit **4**. The second interface unit **5** transfers the batch-processed substrates W to the single-wafer processing unit **6**. The substrates W transferred to the single-wafer processing unit **6** are subjected to the single-wafer processing in the single-wafer processing unit **6**. In this way, the substrates W distributed to the batch processing unit **4** are returned to the cassette C in the loader **23** after being subjected to the complex processing including the batch processing and the single-wafer processing.

[0080] If a second cassette to be subjected to the single-wafer processing is transferred to the loader **23** while the complex processing is being performed on the substrate W taken out from the first cassette, the first interface unit **3** distributes substrates W accommodated in the second cassette to the single-wafer processing unit **6**. The substrates W distributed to the single-wafer processing unit **6** are subjected to the single-wafer processing in the single-wafer processing unit **6**.

[0081] In this way, according to the substrate processing method of the present exemplary embodiment, the complex processing including the batch processing and the single-wafer processing, and the single-wafer processing without passing through the batch processing unit **4** can be performed in parallel.

[0082] The first cassette as the target of the complex processing is a cassette which accommodates therein product substrates, for example. The second cassette as the target of the single-wafer processing is a cassette that accommodates therein dummy substrates, for example. In this case, the complex processing for the product substrates and a dummy processing in the single-wafer processing unit **6** using the dummy substrates can be performed in parallel. The dummy processing may be, for example, a processing of performing components replacement or the like on at least one drying apparatus **63** among the drying apparatuses **63** arranged in multiple levels and then putting a plurality of dummy substrates into that drying apparatus **63** to improve cleanliness thereof. Unlike the product substrates, the dummy substrates do not need to be subjected to the batch processing (for example, the chemical liquid processing). By transferring the dummy substrates to the single-wafer processing unit **6** without passing through the batch processing unit **4**, unnecessary transportation can be omitted, and the time required for the dummy processing can be shortened. Further, the first cassette may accommodate first product substrates to be subjected to the complex processing, and the second cassette may accommodate second product substrates to be subjected to the single-wafer processing only.

[0083] In addition, the second cassette, which is the target of the single-wafer processing, may be a cassette that accommodates therein the product substrates. In this case, the complex processing on the product substrates and the single-wafer processing on the product substrates can be performed in parallel. Further, the first cassette to be subjected to the complex processing may be a cassette accommodating therein the dummy substrates. In this way, the types of the substrates accommodated by the first cassette and the second cassette are not limited. Also, for three or more cassettes C, the complex processing and the single-wafer processing can be performed in parallel in the same manner.

[0084] The exemplary embodiments disclosed herein are illustrative in all aspects and do not limit the present disclosure. The above-described exemplary embodiments may be omitted, replaced and modified in various ways without departing from the scope and the spirit of the appended claims.

[0085] According to the exemplary embodiment, it is possible to perform the complex processing including the batch processing and the single-wafer processing, and the single-wafer processing in parallel.

[0086] From the foregoing, it will be appreciated that various embodiments of the present disclosure have been described herein for purposes of illustration, and that various modifications may be made without departing from the scope and spirit of the present disclosure. Accordingly, the various embodiments disclosed herein are not intended to be limiting. The scope of the inventive concept is defined by the following claims and their equivalents rather than by the detailed description of the exemplary embodiments. It shall be understood that all modifications and embodiments conceived from the meaning and scope of the claims and their equivalents are included in the scope of the inventive concept.

[0087] The claims of the present application are different and possibly, at least in some aspects, broader in scope than the claims pursued in the parent application. To the extent any prior amendments or characterizations of the scope of any claim or cited document made during prosecution of the parent could be construed as a disclaimer of any subject matter supported by the present disclosure, Applicants hereby rescind and retract such disclaimer. Accordingly, the references previously presented in the parent applications may need to be revisited.

Claims

1. A substrate processing system, comprising: a carry-in/out unit in which a cassette accommodating therein multiple substrates is carried in and out; a batch processing unit configured to process a lot including the multiple substrates at once; a single-wafer processing unit configured to process the multiple substrates one by one; and a first interface unit configured to distribute the multiple substrates accommodated in the cassette to either the single-wafer processing unit or the batch processing unit, wherein the first interface unit comprises a first transfer device configured to transfer dummy substrates accommodated in the cassette to the single-wafer processing unit, and to transfer product substrates accommodated in the cassette to the batch processing unit.

2. The substrate processing system of claim 1, wherein the first interface unit comprises: a first placement unit configured to place therein the dummy substrates before and after being processed by the single-wafer processing unit; and a second placement unit configured to place therein the product substrates before being processed by the batch processing unit.
3. The substrate processing system of claim 2, wherein the single-wafer processing unit comprises: a liquid processing apparatus configured to process the multiple substrates one by one with a processing liquid; a drying apparatus configured to dry the multiple substrates one by one with a supercritical fluid; and a second transfer device configured to transfer the multiple substrates among the first placement unit, the liquid processing apparatus, and the drying apparatus.
4. The substrate processing system of claim 1, wherein the cassette comprises: a first cassette accommodating therein the product substrates, and being a target of a complex processing; and a second cassette accommodating therein the dummy substrates, and being a target of a single-wafer processing.
5. A substrate processing method performed in a substrate processing system including a carry-in/out unit in which a cassette accommodating therein multiple substrates is carried in and out; a batch processing unit configured to process a lot including the multiple substrates at once; and a single-wafer processing unit configured to process the multiple substrates one by one, the substrate processing method comprising: (a) transferring dummy substrates from the cassette to the single-wafer processing unit without passing through the batch processing unit, and returning the processed dummy substrates back to the cassette; and (b) transferring the lot including the multiple substrates accommodated in the cassette to the batch processing unit, and processing the lot at once in the batch processing unit.
6. The substrate processing method of claim 5, wherein the (a) and the (b) are performed in parallel.