US Patent & Trademark Office
Patent Public Search | Text View

United States Patent	12392033
Kind Code	B2
Date of Patent	August 19, 2025
Inventor(s)	Furuya; Yuichi et al.

Substrate processing apparatus and substrate processing method

Abstract

A substrate processing apparatus according to an aspect of the present disclosure is an apparatus that deposits a film on a substrate disposed in a processing chamber, and includes a process gas supply configured to supply, into the processing chamber, a process gas including a source gas and a carrier gas that carries the source gas, a vacuum pump configured to exhaust an interior of the processing chamber, and a purge gas supply configured to supply a purge gas into the vacuum pump. The purge gas includes a first gas that is identical to the carrier gas.

Inventors:	**Furuya; Yuichi (Yamanashi, JP), Hara; Masamichi (Yamanashi, JP)**
Applicant:	**Tokyo Electron Limited** (Tokyo, JP)
Family ID:	**1000008762927**
Assignee:	**Tokyo Electron Limited (Tokyo, JP)**
Appl. No.:	**18/255407**
Filed (or PCT Filed):	**December 01, 2021**
PCT No.:	**PCT/JP2021/044135**
PCT Pub. No.:	**WO2022/130985**
PCT Pub. Date:	June 23, 2022

Prior Publication Data

Document Identifier	Publication Date
US 20240093362 A1	Mar. 21, 2024

Foreign Application Priority Data

JP	2020-207526	Dec. 15, 2020

Publication Classification

Int. Cl.: **C23C16/44** (20060101); **C23C16/16** (20060101); **C23C16/52** (20060101)

U.S. Cl.:

CPC **C23C16/4412** (20130101); **C23C16/16** (20130101); **C23C16/52** (20130101);

Field of Classification Search

CPC: C23C (16/52)

References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
2002/0094277	12/2001	Gaudet	417/44.1	F04D 15/0066
2005/0120955	12/2004	Yamasaki	118/715	C23C 16/16
2006/0222768	12/2005	Faguet	N/A	N/A
2013/0000558	12/2012	Hara	118/724	C23C 16/4412
2014/0295675	12/2013	Ikeuchi	118/704	H01L 21/67109

FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
102112206	12/2010	CN	N/A
H04-059393	12/1991	JP	N/A
2000-277503	12/1999	JP	N/A
2002-134498	12/2001	JP	N/A
2006-339461	12/2005	JP	N/A
2008-244298	12/2007	JP	N/A
200716778	12/2006	TW	N/A
2004/007797	12/2003	WO	N/A

Primary Examiner: Murata; Austin

Attorney, Agent or Firm: IPUSA, PLLC

Background/Summary

TECHNICAL FIELD
(1) The present disclosure relates to a substrate processing apparatus and a substrate processing method.
BACKGROUND ART
(2) In order to prevent corrosion or film deposition in a turbo molecular pump, a technique of introducing an inert gas into an exhaust system during operation of the pump is known (for example, see Patent Document 1). Additionally, a technique of depositing a Ru film by supplying Ru.sub.3(CO).sub.12 gas into a processing chamber, using CO gas as a carrier gas is known (for example, see Patent Document 2).

RELATED-ART DOCUMENTS
Patent Document
(3) [Patent Document 1] Japanese Unexamined Utility Model Application Publication No. H4-59393 [Patent Document 2] Japanese Unexamined Patent Application Publication No. 2008-244298
SUMMARY OF THE INVENTION
Problem to be Solved by the Invention
(4) The present disclosure provides a technique of suppressing adhesion of a film to the interior of a vacuum pump.
Means for Solving Problem
(5) A substrate processing apparatus according to an aspect of the present disclosure is an apparatus that deposits a film on a substrate disposed in a processing chamber, and includes a process gas supply configured to supply, into the processing chamber, a process gas including a source gas and a carrier gas that carries the source gas, a vacuum pump configured to exhaust an interior of the processing chamber, and a purge gas supply configured to supply a purge gas into the vacuum pump. The purge gas includes a first gas that is identical to the carrier gas.
Effect of Invention
(6) According to the present disclosure, adhesion of a film to the interior of a vacuum pump can be suppressed.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** is a schematic view illustrating an example of a substrate processing apparatus according to an embodiment.
(2) FIG. **2** is a schematic cross-sectional view illustrating an example of a turbo molecular pump of the embodiment.
(3) FIG. **3** is a diagram illustrating an example of a substrate processing method of the embodiment.
DESCRIPTION OF EMBODIMENTS
(4) In the following, non-restrictive embodiments of the present disclosure will be described with reference to the accompanying drawings. In all of the accompanying drawings, the same or corresponding members or components are denoted by the same or corresponding reference symbols, and duplicated description is omitted.
(5) [Substrate Processing Apparatus]
(6) An example of a substrate processing apparatus according to an embodiment will be described with reference to FIG. **1**. In the following, as an example of the substrate processing apparatus, a substrate processing apparatus configured to deposit a ruthenium (Ru) film by a chemical vapor deposition (CVD) method will be described.
(7) A film deposition apparatus **1** includes a processing section **10**, a process gas supply **20**, an exhaust section **30**, and a controller **90**.
(8) The processing section **10** performs a film deposition process of depositing a Ru film on a substrate W. The substrate W may be, for example, a semiconductor wafer. The processing section **10** includes a processing chamber **11** and a mounting table **12**. The interior of the processing chamber **11** is depressurized by the exhaust section **30**. The mounting table **12** is provided in the processing chamber **11**. The mounting table **12** holds the substrate in the processing chamber **11**.
(9) The process gas supply **20** supplies Ru.sub.3(CO).sub.12 gas, which is an example of a source gas, to the processing section **10**. The process gas supply **20** includes a source container **21**, a gas introduction line **22**, a bubbling gas line **23**, and a flow rate controller **24**. The Ru.sub.3(CO).sub.12

is stored in the source container **21**. The bubbling gas line **23** supplies, to the source container **21**, carbon monoxide (CO) gas whose flow rate is controlled by the flow rate controller **24**. This causes the Ru.sub.3(CO).sub.12 to be vaporized in the source container **21**, and the Ru.sub.3(CO).sub.12 gas is supplied into the processing chamber **11** through the gas introduction line **22**. Additionally, the process gas supply **20** includes a carrier gas line **25** and a flow rate controller **26**. The carrier gas line **25** supplies CO gas, which is an example of a carrier gas whose flow rate is controlled by the flow rate controller **26**, to the gas introduction line **22**, and carries the Ru.sub.3(CO).sub.12 gas into the processing chamber **11**. Additionally, the process gas supply **20** includes a purge line **27** and a flow rate controller **28**. The purge line **27** supplies an inert gas, such as argon (Ar), whose flow rate is controlled by the flow rate controller **28** into the processing chamber **11** through the gas introduction line **22**.

(10) The exhaust section **30** exhausts the interior of the processing chamber **11**. The exhaust section **30** includes an exhaust line **31**, a pressure control valve **32**, a turbo molecular pump **33**, a valve **34**, and a dry pump **35**. The pressure control valve **32**, the turbo molecular pump **33**, the valve **34**, and the dry pump **35** are provided in the exhaust line **31** in this order from the processing chamber **11** side. Additionally, the exhaust section **30** includes a bypass line **36** that connects a portion between the processing chamber **11** and the pressure control valve **32** in the exhaust line **31** and a portion between the valve **34** and the dry pump **35** in the exhaust line **31** and that bypasses the turbo molecular pump **33**. The bypass line **36** is used when the interior of the processing chamber **11** is roughly evacuated by the dry pump **35**. The bypass line **36** is provided with a valve **37**. Additionally, the exhaust section **30** includes a purge gas supply **38**. The purge gas supply **38** supplies a purge gas into the turbo molecular pump **33**. The purge gas supply **38** includes a CO gas line **38***a* and a N.sub.2 gas line **38***b*. The CO gas line **38***a* supplies CO gas into the turbo molecular pump **33**. The N.sub.2 gas line **38***b* supplies N.sub.2 gas into the turbo molecular pump **33**. The CO gas line **38***a* and the N.sub.2 gas line are respectively provided with valves **38***c* and **38***d*. By opening the valve **38***c* and closing the valve **38***d*, CO gas is supplied from the CO gas line **38***a* into the turbo molecular pump **33**. Conversely, by closing the valve **38***c* and opening the valve **38***d*, N.sub.2 gas is supplied from the N.sub.2 gas line **38***b* into the turbo molecular pump **33**.

(11) The controller **90** controls the processing section **10**, the process gas supply **20**, and the exhaust section **30** to perform a substrate processing method of the embodiment to be described later. The controller **90** may be, for example, a computer.

(12) [Turbo Molecular Pump]

(13) An example of a turbo molecular pump (TMP) of the embodiment will be described with reference to FIG. **2**. A turbo molecular pump **100** described below is applicable as the turbo molecular pump **33** of the film deposition apparatus **1** described above.

(14) The turbo molecular pump **100** includes a casing **101**, a base **102**, a motor housing **103**, bearings **104** and **105**, a shaft **106**, a rotor **107**, a pump mechanism **108**, an oil tank **109**, an inlet flange **110**, an exhaust flange **111**, and a purge gas supply **120**.

(15) The casing **101** is a cylindrical body. The casing **101** accommodates the motor housing **103** and the like.

(16) The base **102** supports the casing **101**.

(17) The motor housing **103** is provided in the casing **101** and fixed on the base **102**. A motor M that rotationally drives the shaft **106** is accommodated in the motor housing **103**.

(18) The bearings **104** and **105** are respectively provided in the motor housing **103** and the base **102**. The bearings **104** and **105** are paired. The bearings **104** and **105** may be, for example, ball bearings or magnetic bearings.

(19) The shaft **106** is supported by the bearings **104** and **105** at the vicinity of both axial ends.

(20) The rotor **107** is fixed to the shaft **106** to be integrally rotatable, and accommodates the motor housing **103** inside an inner circumferential surface **107***a*.

(21) The pump mechanism **108** includes a turbine **108***a* and a screw rotor **108***b*. The turbine **108***a*

and the screw rotor **108***b* are provided between an outer circumferential surface **107***b* of the rotor **107** and an inner circumferential surface **101***a* of the casing **101**. The turbine **108***a* is formed by alternately arranging a rotating blade **107***c* projecting from the rotor **107** and a fixed blade **101***b* projecting from the inner circumferential surface **101***a* of the casing **101**. The screw rotor **108***b* is formed by inserting a blade **101***c* projecting from the inner circumferential surface **101***a* of the casing **101** into a spiral groove **107***d* formed on the outer circumferential surface of the lower end portion of the rotor **107** in a non-contact and close manner.
(22) The oil tank **109** is attached to the bottom of the base **102**.
(23) The inlet flange **110** is fixed to an upper end of the casing **101**. The inlet flange **110** includes an inlet port **110***a* through which gas is suctioned.
(24) The exhaust flange **111** is fixed to the bottom of the base **102**. The exhaust flange **111** includes an exhaust port **111***a* for exhausting the gas suctioned from the inlet port **110***a*.
(25) The purge gas supply **120** supplies the purge gas into the motor housing **103**. In one embodiment, the purge gas supply **120** supplies the purge gas from a lower side to an upper side along the outer circumferential surface of the shaft **106** (see arrow F in FIG. **2**). The purge gas supply **120** includes a CO gas supply **121** and a N.sub.2 gas supply **122**.
(26) The CO gas supply **121** includes a CO gas supply source **121***a*, a gas line **121***b*, a flow rate controller **121***c*, a valve **121***d*, and the like. The CO gas supply **121** supplies, into the motor housing **103**, the CO gas supplied from the CO gas supply source **121***a* by the flow rate controller **121***c* controlling the flow rate.
(27) The N.sub.2 gas supply **122** includes a N.sub.2 gas supply source **122***a*, a gas line **122***b*, a flow rate controller **122***c*, a valve **122***d*, and the like. The N.sub.2 gas supply **122** supplies, into the motor housing **103**, the N.sub.2 gas supplied from the N.sub.2 gas supply source **122***a* by the flow rate controller **122***c* controlling the flow rate.
(28) The purge gas supply **120** controls the opening and closing of the valves **121***d* and **122***d* to switch the purge gas to be supplied into the motor housing **103** between CO gas and N.sub.2 gas.
(29) In the turbo molecular pump **100** described above, the gas suctioned from the inlet port **110***a* is compressed by the pump mechanism **108** and forcibly exhausted toward the exhaust port **111***a*.
(30) Here, in the example illustrated in FIG. **2**, an embodiment in which the purge gas supply **120** supplies the purge gas into the motor housing **103** has been described, but the present invention is not limited thereto. The purge gas supply **120** may be configured to supply the purge gas to another place in the turbo molecular pump **100**.
(31) [Substrate Processing Method]
(32) An example of the substrate processing method of the embodiment will be described with reference to FIG. **3**. In the following, a case where a Ru film is deposited on the substrate W in the above-described film deposition apparatus **1** will be described as an example. Here, the valve **38***c* is in a closed state and the valve **38***d* is in an open state at the time of the start of the following substrate processing method. That is, it is assumed that N.sub.2 gas is supplied as the purge gas into the turbo molecular pump **33** at the time of the start of the substrate processing method.
(33) In step S**1**, the controller **90** controls each component of the film deposition apparatus **1** to transfer the substrate W into the processing chamber **11** and mount the substrate W on the mounting table **12**.
(34) Step S**2** is performed after step S**1**. However, step S**2** may be performed before step S**1**, or may be performed simultaneously with step S**1**. In step S**2**, the controller **90** switches the purge gas to be supplied into the turbo molecular pump **33** from N.sub.2 gas to CO gas. In one embodiment, the controller **90** stops the supply of N.sub.2 gas into the turbo molecular pump **33** by closing the valve **38***d* and starts the supply of CO gas into the turbo molecular pump **33** by opening the valve **38***c*.
(35) Step S**3** is performed after step S**2**. However, the step S**3** may be performed simultaneously with the step S**2**. In step S**3**, the controller **90** controls each component of the film deposition

apparatus **1** to perform the film deposition process on the substrate W mounted on the mounting table **12** in the processing chamber **11**. In one embodiment, the controller **90** controls the process gas supply **20** to supply Ru.sub.3(CO).sub.12 gas into the processing chamber **11** together with CO gas, thereby depositing the Ru film on the substrate W. Additionally, part of the Ru.sub.3(CO).sub.12 gas supplied into the processing chamber **11** is not used in the film deposition process and exhausted by the turbo molecular pump **33**. At this time, because CO gas is supplied as the purge gas into the turbo molecular pump **33**, Ru.sub.3(CO).sub.12 gas is exhausted together with CO gas.
(36) Step S**4** is performed after step S**3**. In step S**4**, the controller **90** determines whether the film deposition process is completed. If it is determined in step S**4** that the film deposition process is completed, the controller **90** advances the process to step S**5**. If it is determined in step S**4** that the film deposition process is not completed, the controller **90** performs step S**4** again.
(37) Step S**5** is performed after step S**4**. In step S**5**, the controller **90** switches the purge gas to be supplied into the turbo molecular pump **33** from CO gas to N.sub.2 gas. In one embodiment, the controller **90** stops the supply of CO gas into the turbo molecular pump **33** by closing the valve **38***c*, and starts the supply of N.sub.2 gas into the turbo molecular pump **33** by opening the valve **38***d*. As described above, by switching the purge gas from CO gas to N.sub.2 gas after the film deposition process is completed, the cost can be reduced by reducing the consumption of CO gas.
(38) Step S**6** is performed after step S**5**. However, step S**6** may be performed simultaneously with step S**5**, or may be performed before step S**5**. In step S**6**, the controller **90** controls each component of the film deposition apparatus **1** to transfer the substrate W that is mounted on the mounting table **12** and on which the film deposition process has been performed, from the processing chamber **11**. Subsequently, the controller **90** ends the process.
(39) The Ru.sub.3(CO).sub.12 compound is decomposed by a reaction represented by the following formula (A) to cause deposition of metal Ru.
Ru.sub.3(CO).sub.12.fwdarw.3Ru+12CO (A)
(40) The reaction represented by the formula (A) advances more as the partial pressure of CO in the atmosphere decreases. Therefore, when part of the Ru.sub.3(CO).sub.12 gas is exhausted by the exhaust section **30** with no reaction in the processing chamber **11** during the film deposition process, Ru.sub.3(CO).sub.12 gas may be decomposed in the turbo molecular pump **33**, piping on the downstream side thereof, and the like and may be deposited as a Ru film. It is conceivable that this is because the N.sub.2 gas supplied as the purge gas into the turbo molecular pump **33** reduces the CO concentration in the atmosphere.
(41) With respect to the above, according to the substrate processing method of the embodiment, the purge gas to be supplied into the turbo molecular pump **33** is switched from N.sub.2 gas to CO gas before the film deposition process is started. Thereby, even when part of the Ru.sub.3(CO).sub.12 gas is exhausted by the exhaust section **30** with no reaction in the processing chamber **11** during the film deposition process, a decrease in the CO concentration in the atmosphere in the turbo molecular pump **33**, the piping on the downstream side thereof, and the like can be suppressed. Therefore, the decomposition reaction of the Ru.sub.3(CO).sub.12 in the turbo molecular pump **33**, the piping on the downstream side thereof, and the like is suppressed, so that the deposition of the Ru film in the turbo molecular pump **33**, the piping on the downstream side thereof, and the like can be suppressed.
(42) Additionally, during the film deposition process, it is preferable to supply CO gas into the turbo molecular pump **33** such that the partial pressure ratio of Ru.sub.3(CO).sub.12 gas to CO gas becomes 1:49 or greater. This can suppress the deposition of the Ru film in the turbo molecular pump **33**, the piping on the downstream side thereof, and the like, thereby preventing the generation of particles.
(43) Here, in the above-described embodiments, CO gas is an example of a first gas, and N.sub.2 gas is an example of a second gas. Additionally, the turbo molecular pumps **33** and **100** are

examples of a vacuum pump, and the valves **38***c*, **38***d*, **121***d*, and **122***d* are examples of a gas switcher.
(44) It should be understood that the embodiments disclosed herein are illustrative and are not restrictive in all respects. The above-described embodiments may be omitted, replaced, and changed in various forms without departing from the scope and spirit of the appended claims.
(45) Although the case where CO gas and N.sub.2 gas are supplied into the turbo molecular pump **33** has been described in the above-described embodiments, the present disclosure is not limited thereto. For example, another inert gas such as Ar gas may be used instead of N.sub.2 gas.
(46) The present international application is based upon and claims the priority to Japanese Patent Application No. 2020-207526 filed on Dec. 15, 2020, the entire contents of which are incorporated herein by reference.
DESCRIPTION OF REFERENCE SYMBOLS
(47) **1** film deposition apparatus **10** processing section **11** processing chamber **20** process gas supply **30** exhaust section **33**, **100** turbo molecular pump **38**, **120** purge gas supply W substrate

Claims

1. A substrate processing apparatus that deposits a film on a substrate disposed in a processing chamber, the substrate processing apparatus comprising: a process gas supply configured to supply a process gas into the processing chamber, the process gas including a source gas and a carrier gas that carries the source gas; a vacuum pump configured to exhaust an interior of the processing chamber; and a purge gas supply configured to supply a purge gas into the vacuum pump, wherein the purge gas includes a first gas that is identical to the carrier gas, wherein the purge gas includes a second gas that is different from the first gas, and wherein the purge gas supply includes a gas switcher configured to switch between a state of supplying the first gas into the vacuum pump and a state of supplying the second gas into the vacuum pump.
2. The substrate processing apparatus as claimed in claim 1, further comprising a controller, wherein the controller is configured to control the purge gas supply to supply the first gas into the vacuum pump in a case where the process gas is supplied from the process gas supply into the processing chamber.
3. The substrate processing apparatus as claimed in claim 1, further comprising a controller, wherein the controller is configured to control the purge gas supply to supply the second gas into the vacuum pump in a case where the process gas is not supplied from the process gas supply into the processing chamber.
4. The substrate processing apparatus as claimed in claim 1, wherein the second gas is an inert gas.
5. The substrate processing apparatus as claimed in claim 1, wherein the vacuum pump is a turbo molecular pump and the purge gas supply supplies the purge gas along a shaft of the turbo molecular pump.
6. The substrate processing apparatus as claimed in claim 1, wherein the source gas is Ru3(CO)12 gas, and the carrier gas and the first gas are CO gas.
7. The substrate processing apparatus as claimed in claim 1, wherein the purge gas supply supplies the purge gas into the vacuum pump such that a partial pressure ratio of the source gas to the first gas becomes 1:49 or greater.
8. A substrate processing method that deposits a film on a substrate disposed in a processing chamber, the substrate processing method comprising: supplying a process gas into the processing chamber while exhausting, by a vacuum pump, an interior of the processing chamber, the process gas including a source gas and a carrier gas that carries the source gas; wherein the supplying of the process gas includes supplying a purge gas into the vacuum pump, the purge gas including a first gas that is identical to the carrier gas, wherein the purge gas includes a second gas that is different from the first gas, and wherein the supplying of the purge gas includes switching between a state of

supplying the first gas into the vacuum pump and a state of supplying the second gas into the vacuum pump.

9. A substrate processing apparatus that deposits a film on a substrate disposed in a processing chamber, the substrate processing apparatus comprising: a process gas supply configured to supply a process gas into the processing chamber, the process gas including a source gas and a carrier gas that carries the source gas; a vacuum pump configured to exhaust an interior of the processing chamber; a purge gas supply configured to supply a purge gas into the vacuum pump; and a controller, wherein the purge gas includes a first gas that is identical to the carrier gas, wherein the purge gas includes a second gas that is different from the first gas, and wherein the controller is configured to control the purge gas supply to supply the first gas into the vacuum pump in a case where the process gas is supplied from the process gas supply into the processing chamber.

10. A substrate processing apparatus that deposits a film on a substrate disposed in a processing chamber, the substrate processing apparatus comprising: a process gas supply configured to supply a process gas into the processing chamber, the process gas including a source gas and a carrier gas that carries the source gas; a vacuum pump configured to exhaust an interior of the processing chamber; a purge gas supply configured to supply a purge gas into the vacuum pump; and a controller, wherein the purge gas includes a first gas that is identical to the carrier gas, wherein the purge gas includes a second gas that is different from the first gas, and wherein the controller is configured to control the purge gas supply to supply the second gas into the vacuum pump in a case where the process gas is not supplied from the process gas supply into the processing chamber.