CONTROL VALVE, SUBSTRATE PROCESSING APPARATUS, METHOD OF MANUFACTURING SEMICONDUCTOR DEVICE, AND PROGRAM

TECHNICAL FIELD

[0001] The present disclosure relates to a control valve, a substrate processing apparatus, a method of manufacturing a semiconductor device, and a program.

BACKGROUND

[0002] In a thin film-forming process in semiconductor device manufacturing, two or more types of film-forming gases may be alternately flowed onto a substrate one by one and may be reacted with atoms on the substrate to deposit a film one layer at a time. At this time, a reaction chamber pressure during film formation differs for each film-forming gas supply event, and pressure regulation thereof is mainly performed by conductance regulation function (APC (Auto Pressure Control)) of an exhaust main valve.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0003] Patent Document 1: Japanese Patent Application Publication No. 2003-183837

Patent Document 2: Japanese Patent Application Publication No. 2010-67788

Patent Document 3: Japanese Patent Application Publication No. 2009-259894

Patent Document 4: Japanese Patent Application Publication No. H11-300193

Patent Document 5: International Publication No. 2017/022366

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0004] In recent film-forming sequences, the number of apparatuses including a high conductance exhaust system (hereinafter referred to as a ″200A exhaust system″) is increasing to

improve an exhaust speed, a gas replacement efficiency, and the like.

[0005] However, in the related art, with a 200A regulating valve, controllability was not sufficient, because there was, for example, difficulty in regulating a pressure with a minute valve opening degree.

[0006] Some embodiments of the present disclosure provide a technique of a control valve with good controllability in response to a large flow rate exhaust from a reaction chamber.

MEANS TO SOLVE THE PROBLEM

[0007] According to embodiments of the present disclosure, there is provided a technique that includes: a gate valve including a movable gate valve plate; and a butterfly valve that is installed at the gate valve plate, has a diameter smaller than those of valve openings configured to be opened or closed by the gate valve plate, and is configured to be capable of being fully closed, wherein the gate valve plate of the gate valve and the butterfly valve are configured to be capable of being driven independently of each other.

EFFECTS OF THE INVENTION

[0008] According to the present disclosure in some embodiments, it is possible to provide a control valve of good controllability in response to large flow rate exhaust from a reaction chamber.

BRIEF DESCRIPTION OF DRAWINGS

[0009] The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the present disclosure.

FIG. 1 is a schematic view showing an overall configuration of a substrate processing apparatus according to embodiments of the present disclosure.

FIG. 2 is a front view showing an exhaust system according to embodiments of the present disclosure.

WHAT IS CLAIMED IS:

1. A control valve comprising:

a gate valve including a movable gate valve plate; and

a butterfly valve that is installed at the gate valve plate, has a diameter smaller than those of valve openings configured to be opened or closed by the gate valve plate, and is configured to be capable of being fully closed,

wherein the gate valve plate of the gate valve and the butterfly valve are configured to be capable of being driven independently of each other.

2. The control valve of Claim 1, wherein a conductance or a flow rate of the control valve is regulated by the butterfly valve such that the gate valve is opened when a set conductance or a set flow rate is larger than a predetermined value, and the gate valve is closed when the set conductance or the set flow rate is smaller than the predetermined value.

3. The control valve of Claim 1, wherein the gate valve further includes a valve housing including two of the valve openings arranged facing each other in a flow path direction and a gate valve seat, and linearly forming a flow path of a controlled fluid between the two valve openings, and

wherein the gate valve plate is configured to move between an open position where the gate valve plate retracts out of the flow path and opens the valve openings and a close position where the gate valve plate protrudes into the flow path and contacts the gate valve seat to seal the valve openings.

4. The control valve of Claim 3, wherein the gate valve further includes:

a driver arranged on the gate valve plate and configured to be capable of moving in a moving direction of the gate valve plate or expanding or contracting in the moving direction of

the gate valve plate together with the gate valve plate;

a gate valve actuator configured to drive the driver in the moving direction of the gate valve plate; and

a gate valve seal ring that is arranged on the gate valve seat or a surface of the gate valve plate facing the gate valve seat and is elastic.

5. The control valve of Claim 4, wherein the butterfly valve includes:

a butterfly valve chamber that is provided through the gate valve plate to allow the two valve openings to be in fluid communication with each other and includes a butterfly valve seat;

a butterfly valve plate that is formed in a shape corresponding to the butterfly valve seat and is rotatably supported around the moving direction of the gate valve plate as an axis;

a shaft that is connected to the butterfly valve plate, extends in the moving direction of the gate valve plate, and is configured to be capable of rotating around the axis; and

a butterfly valve actuator configured to drive the shaft to rotate around the axis.

6. The control valve of Claim 4, wherein the gate valve seat is installed on an upstream side of the gate valve plate, and

wherein the gate valve seal ring is installed at the gate valve seat or the surface of the gate valve plate facing the gate valve seat.

7. The control valve of Claim 5, wherein the butterfly valve is arranged on an outer periphery of the butterfly valve plate, includes an elastic butterfly valve seal ring that abuts on the butterfly valve seat, and is configured to be capable of sealing the butterfly valve seat with the butterfly valve seal ring.

8. The control valve of Claim 3, wherein the valve openings are formed in a circular shape, and the valve housing forms the flow path such that a cross section of the flow path is equal to or

larger than those of the valve openings.

9. The control valve of Claim 5, wherein the two valve openings are separated from each other at a distance wider than a size of the butterfly valve plate in the flow path direction of the valve housing.

10. The control valve of Claim 7, further comprising a valve controller configured to control an opening state of the butterfly valve plate to be less than a predetermined opening state when the gate valve is fully opened.

11. The control valve of Claim 4, wherein the gate valve seat and the surface of the gate valve plate facing the gate valve seat are inclined with respect to the moving direction of the gate valve plate and are arranged in parallel with each other.

12. The control valve of Claim 5, further comprising:

a linear motion feedthrough configured to connect the driver to the gate valve actuator installed outside the valve housing while an inside and an outside of the valve housing are isolated from each other; and

a linear motion rotary feedthrough configured to connect the shaft to the butterfly valve actuator installed outside the valve housing while the inside and the outside of the valve housing are isolated from each other.

13. The control valve of Claim 5, wherein areas of the valve openings are equal to or larger than a cross-sectional area of a pipe whose nominal diameter is 200A,

wherein an area of an opening in the butterfly valve seat is equal to or smaller than a cross-sectional area of a pipe whose nominal diameter is 100A, and

wherein the control valve is used in a vacuum exhaust flow path from a reaction

chamber of a substrate processing apparatus.

14. A substrate processing apparatus comprising:

a process chamber configured to process a substrate;

a sensor configured to detect an internal pressure of the process chamber; and

a control valve that is installed between the process chamber and an exhaust pump and is controlled according to the internal pressure,

wherein the control valve includes:

a gate valve including a movable gate valve plate; and

a butterfly valve that is installed at the gate valve plate, has a diameter smaller than those of valve openings configured to be opened or closed by the gate valve plate, and is configured to be capable of being fully closed,

wherein the gate valve plate of the gate valve and the butterfly valve are configured to be capable of being driven independently of each other.

15. A method of manufacturing a semiconductor device, comprising:

loading a substrate into a reaction chamber of a substrate processing apparatus;

controlling a control valve to exhaust the reaction chamber such that a pressure of the reaction chamber becomes a predetermined pressure, the control valve including a gate valve including a movable gate valve plate and a butterfly valve that is installed at the gate valve plate, has a diameter smaller than those of valve openings opened or closed by the gate valve plate, and is configured to be capable of being fully closed, and the gate valve plate of the gate valve and the butterfly valve being configured to be capable of being driven independently of each other; and

processing the substrate in the reaction chamber.

16. A program that causes, by a computer, a substrate processing apparatus to perform a process comprising:

loading a substrate into a reaction chamber of the substrate processing apparatus;

controlling a control valve to exhaust the reaction chamber such that a pressure of the reaction chamber becomes a predetermined pressure, the control valve including a gate valve including a movable gate valve plate and a butterfly valve that is installed at the gate valve plate, has a diameter smaller than those of valve openings opened or closed by the gate valve plate, and is configured to be capable of being fully closed, and the gate valve plate of the gate valve and the butterfly valve being configured to be capable of being driven independently of each other; and

processing the substrate in the reaction chamber..