

What is claimed is:

1. A method of creating a polishing-rate responsiveness profile indicating a distribution of polishing-rate responsiveness to pressure change in a first pressure chamber and a second pressure chamber when a workpiece used for manufacturing a semiconductor device is pressed against a polishing pad with an elastic membrane forming the first pressure chamber and the second pressure chamber, the method comprising:

creating an estimated polishing-rate responsiveness profile using simulation, the estimated polishing-rate responsiveness profile indicating a distribution of polishing-rate responsiveness to pressure change in the first pressure chamber;

creating an actual polishing-rate responsiveness profile using polishing results of a workpiece, the actual polishing-rate responsiveness profile indicating a distribution of polishing-rate responsiveness to pressure change in the second pressure chamber; and

creating a hybrid polishing-rate responsiveness profile by combining the estimated polishing-rate responsiveness profile and the actual polishing-rate responsiveness profile.

2. The method according to claim 1, wherein creating the estimated polishing-rate responsiveness profile comprises:

performing simulation to calculate a pressing-pressure responsiveness profile indicating a distribution of pressing pressure changed in response to a change in unit pressure in the first pressure chamber, the pressing pressure being applied from a first workpiece to the polishing pad in the simulation;

polishing the first workpiece by pressing the first workpiece against the polishing pad while maintaining a predetermined pressure in the first pressure chamber;

creating a polishing-rate profile indicating a distribution of polishing rate of the polished first workpiece; and

creating the estimated polishing-rate responsiveness profile based on the pressing-pressure responsiveness profile, the predetermined pressure, and the polishing-rate profile.

3. The method according to claim 2, wherein creating the estimated polishing-rate responsiveness profile comprises:

5 multiplying the pressing-pressure responsiveness profile by the predetermined pressure and a polishing-rate coefficient to create a virtual polishing-rate profile;

determining the polishing-rate coefficient that minimizes a difference between the polishing-rate profile and the virtual polishing-rate profile; and

10 multiplying the pressing-pressure responsiveness profile by the determined polishing-rate coefficient to create the estimated polishing-rate responsiveness profile.

4. The method according to claim 2, wherein calculating the pressing-pressure responsiveness profile comprises:

15 performing simulation to calculate a distribution of first pressing pressure when a gas having a first pressure is supplied into the first pressure chamber and a distribution of second pressing pressure when a gas having a second pressure is supplied into the first pressure chamber; and

20 calculating a pressing pressure changed in response to a change in unit pressure of gas in the first pressure chamber by dividing a difference between the first pressing pressure and the second pressing pressure by a difference between the first pressure and the second pressure at each of radial positions on the first workpiece.

5. The method according to claim 2, wherein creating the actual polishing-rate responsiveness profile comprises:

25 polishing a second workpiece by pressing the second workpiece against the polishing pad while changing the pressure in the second pressure chamber;

calculating polishing rates of the second workpiece corresponding to different pressures in the second pressure chamber; and

calculating polishing-rate responsiveness to pressure change in the second pressure

chamber.

6. The method according to claim 1, wherein creating the estimated polishing-rate responsiveness profile and the actual polishing-rate responsiveness profile comprises:

5 polishing a first workpiece by pressing the first workpiece against the polishing pad while a predetermined first pressure is maintained in the first pressure chamber and a predetermined second pressure is maintained in the second pressure chamber;

 creating an actual polishing-rate profile indicating a distribution of polishing rates of the polished first workpiece;

10 creating a first polishing-rate profile based on the first pressure, a first polishing-rate coefficient, and a pressing-pressure responsiveness profile calculated by simulation;

 creating a second polishing-rate profile based on the second pressure, a second polishing-rate coefficient, and a provisional polishing-rate responsiveness profile created from polishing results of a second workpiece;

15 creating a third polishing-rate profile by combining the first polishing-rate profile and the second polishing-rate profile;

 determining the first polishing-rate coefficient and the second polishing-rate coefficient that minimize a difference between the actual polishing-rate profile and the third polishing-rate profile;

20 creating the estimated polishing-rate responsiveness profile by multiplying the determined first polishing-rate coefficient by the pressing-pressure responsiveness profile; and

 creating the actual polishing-rate responsiveness profile by multiplying the determined second polishing-rate coefficient by the provisional polishing-rate
25 responsiveness profile.

7. The method according to claim 6, wherein calculating the pressing-pressure responsiveness profile comprises:

performing simulation to calculate a distribution of first pressing pressure when a gas having a third pressure is supplied into the first pressure chamber and a distribution of second pressing pressure when a gas having a fourth pressure is supplied into the first pressure chamber; and

5 calculating a pressing pressure changed in response to a change in unit pressure of gas in the first pressure chamber by dividing a difference between the first pressing pressure and the second pressing pressure by a difference between the third pressure and the fourth pressure at each of radial positions on the first workpiece.

10 8. A polishing method comprising:

 optimizing a polishing condition for a workpiece using the hybrid polishing-rate responsiveness profile created by the method according to any one of claims 1 to 7; and

 polishing the workpiece by pressing the workpiece against the polishing pad with the elastic membrane under the optimized polishing condition.

15

 9. A polishing apparatus for polishing a workpiece, comprising:

 a polishing table configured to support a polishing pad having a polishing surface;

 a polishing head configured to press the workpiece against the polishing surface;

and

20 an arithmetic system including a memory storing a program therein and a processor configured to execute arithmetic operations according to instructions included in the program,

 wherein the polishing head has an elastic membrane forming a first pressure chamber and a second pressure chamber,

25 the arithmetic system is configured to create a polishing-rate responsiveness profile indicating a distribution of polishing-rate responsiveness to pressure change in the first pressure chamber and the second pressure chamber when the workpiece is pressed against the polishing pad with the elastic membrane,

the arithmetic system is configured to:

create an estimated polishing-rate responsiveness profile using simulation, the estimated polishing-rate responsiveness profile indicating a distribution of polishing-rate responsiveness to pressure change in the first pressure chamber;

5 create an actual polishing-rate responsiveness profile using polishing results of a workpiece, the actual polishing-rate responsiveness profile indicating a distribution of polishing-rate responsiveness to pressure change in the second pressure chamber; and

create a hybrid polishing-rate responsiveness profile by combining the estimated polishing-rate responsiveness profile and the actual polishing-rate responsiveness profile.

10

10. The polishing apparatus according to claim 9, wherein the arithmetic system is configured to:

perform simulation to calculate a pressing-pressure responsiveness profile indicating a distribution of pressing pressure changed in response to a change in unit
15 pressure in the first pressure chamber, the pressing pressure being applied from a first workpiece to the polishing pad in the simulation;

polish the first workpiece by pressing the first workpiece against the polishing pad while maintaining a predetermined pressure in the first pressure chamber;

create a polishing-rate profile indicating a distribution of polishing rate of the
20 polished first workpiece; and

create the estimated polishing-rate responsiveness profile based on the pressing-pressure responsiveness profile, the predetermined pressure, and the polishing-rate profile.

11. The polishing apparatus according to claim 10, wherein the arithmetic system is
25 configured to:

multiply the pressing-pressure responsiveness profile by the predetermined pressure and a polishing-rate coefficient to create a virtual polishing-rate profile;

determine the polishing-rate coefficient that minimizes a difference between the

polishing-rate profile and the virtual polishing-rate profile; and

multiply the pressing-pressure responsiveness profile by the determined polishing-rate coefficient to create the estimated polishing-rate responsiveness profile.

5 12. The polishing apparatus according to claim 10, wherein the arithmetic system is configured to calculate the pressing-pressure responsiveness profile by:

performing simulation to calculate a distribution of first pressing pressure when a gas having a first pressure is supplied into the first pressure chamber and a distribution of second pressing pressure when a gas having a second pressure is supplied into the first
10 pressure chamber; and

calculating a pressing pressure changed in response to a change in unit pressure of gas in the first pressure chamber by dividing a difference between the first pressing pressure and the second pressing pressure by a difference between the first pressure and the second pressure at each of radial positions on the first workpiece.

15 13. The polishing apparatus according to claim 10, wherein the arithmetic system is configured to create the actual polishing-rate responsiveness profile by:

polishing a second workpiece by pressing the second workpiece against the polishing pad while changing the pressure in the second pressure chamber;

20 calculating polishing rates of the second workpiece corresponding to different pressures in the second pressure chamber; and

calculating polishing-rate responsiveness to pressure change in the second pressure chamber.

25 14. The polishing apparatus according to claim 9, wherein the arithmetic system is configured to:

create an actual polishing-rate profile indicating a distribution of polishing rates of a first workpiece that has been polished by being pressed by the polishing head against the

polishing pad while a predetermined first pressure is maintained in the first pressure chamber and a predetermined second pressure is maintained in the second pressure chamber;

create a first polishing-rate profile based on the first pressure, a first polishing-rate coefficient, and a pressing-pressure responsiveness profile calculated by simulation;

5 create a second polishing-rate profile based on the second pressure, a second polishing-rate coefficient, and a provisional polishing-rate responsiveness profile created from polishing results of a second workpiece;

create a third polishing-rate profile by combining the first polishing-rate profile and the second polishing-rate profile;

10 determine the first polishing-rate coefficient and the second polishing-rate coefficient that minimize a difference between the actual polishing-rate profile and the third polishing-rate profile;

create the estimated polishing-rate responsiveness profile by multiplying the determined first polishing-rate coefficient by the pressing-pressure responsiveness profile;

15 and

create the actual polishing-rate responsiveness profile by multiplying the determined second polishing-rate coefficient by the provisional polishing-rate responsiveness profile.

20 15. The polishing apparatus according to claim 14, wherein the arithmetic system is configured to calculate the pressing-pressure responsiveness profile by:

performing simulation to calculate a distribution of first pressing pressure when a gas having a third pressure is supplied into the first pressure chamber and a distribution of second pressing pressure when a gas having a fourth pressure is supplied into the first

25 pressure chamber; and

calculating a pressing pressure changed in response to a change in unit pressure of gas in the first pressure chamber by dividing a difference between the first pressing pressure and the second pressing pressure by a difference between the third pressure and the fourth

pressure at each of radial positions on the first workpiece.

16. The polishing apparatus according to claim 9, wherein the arithmetic system is configured to optimize a polishing condition using the hybrid polishing-rate responsiveness
5 profile, and

the polishing head is configured to polish a workpiece by pressing the workpiece against the polishing pad with the elastic membrane under the optimized polishing condition.