

What is claimed is:

1. A polishing head system for polishing a workpiece by pressing the workpiece against a polishing surface while moving the workpiece and the polishing surface relative to each other in a presence of a polishing liquid, comprising:
 - a polishing head having a plurality of actuators configured to apply pressing forces to a plurality of regions of the workpiece;
 - a drive source configured to operate the plurality of actuators; and
 - an operation controller configured to determine a plurality of instruction values and transmits the plurality of instruction values to the drive source,wherein the plurality of actuators comprise a plurality of piezoelectric elements, the drive source comprises a drive-voltage application device including a power supply unit and a voltage controller, the power supply unit is configured to apply voltages to the plurality of piezoelectric elements independently, the operation controller is configured to determine a plurality of instruction values of the voltages to be applied to the plurality of piezoelectric elements, the polishing head further includes a plurality of pressing members coupled to the plurality of piezoelectric elements, respectively, the plurality of pressing members has a plurality of first surfaces facing the plurality of piezoelectric elements, respectively, and a plurality of second surfaces for pressing the workpiece, the plurality of pressing members include a plurality of gimbal mechanisms, respectively, the plurality of gimbal mechanisms having a plurality of movable members which are tiltable in all directions, and the plurality of movable members have the plurality of second surfaces, respectively.

2. The polishing head system according to claim 1, wherein the plurality of piezoelectric elements are arranged along a radial direction and a circumferential direction of the polishing head.

5 3. The polishing head system according to claim 2, wherein an arrangement of the plurality of piezoelectric elements in the polishing head is any one or a combination of a grid arrangement, a concentric arrangement, and a staggered arrangement.

10 4. The polishing head system according to claim 1, wherein the plurality of second surfaces have at least one of a circular shape, an ellipse shape, a polygonal shape, and an arc shape.

15 5. The polishing head system according to claim 1 or 4, wherein a facing area of the plurality of first surfaces is larger than a facing area of the plurality of second surfaces.

 6. The polishing head system according to any one of claims 1 to 5, wherein at least two piezoelectric elements are coupled to one pressing member.

20 7. The polishing head system according to claim 1, wherein the polishing head further includes a holding member holding the plurality of pressing members such that the plurality of pressing members are movable within a limited range.

25 8. The polishing head system according to claim 7, wherein the holding member is configured to limit a range of movement of the plurality of pressing members in a direction perpendicular to a direction of pressing the workpiece.

 9. The polishing head system according to any one of claims 1 to 8, wherein the polishing head further includes an elastic membrane having a contact surface with the

workpiece.

10. A polishing head system for polishing a workpiece by pressing the workpiece against a polishing surface while moving the workpiece and the polishing surface relative to each other in a presence of a polishing liquid, comprising:

a polishing head having a plurality of actuators configured to apply pressing forces to a plurality of regions of the workpiece;

an elastic membrane forming a pressure chamber in the polishing head;

a compressed-gas supply line communicating with the pressure chamber;

10 a drive source configured to operate the plurality of actuators; and

an operation controller configured to determine a plurality of instruction values and transmits the plurality of instruction values to the drive source,

wherein the plurality of actuators comprise a plurality of piezoelectric elements,

15 the drive source comprises a drive-voltage application device including a power supply unit and a voltage controller,

the power supply unit is configured to apply voltages to the plurality of piezoelectric elements independently,

the operation controller is configured to determine a plurality of instruction values of the voltages to be applied to the plurality of piezoelectric elements,

20 the polishing head further includes a plurality of pressing members coupled to the plurality of piezoelectric elements, respectively,

the plurality of pressing members has a plurality of first surfaces facing the plurality of piezoelectric elements, respectively, and a plurality of second surfaces for pressing the workpiece, and

25 the pressure chamber is located between the plurality of pressing members and the elastic membrane.

11. A polishing head system for polishing a workpiece by pressing the workpiece

against a polishing surface while moving the workpiece and the polishing surface relative to each other in a presence of a polishing liquid, comprising:

a polishing head having a plurality of actuators configured to apply pressing forces to a plurality of regions of the workpiece;

5 an elastic sheet forming a pressure chamber in the polishing head;

a compressed-gas supply line communicating with the pressure chamber;

a drive source configured to operate the plurality of actuators; and

an operation controller configured to determine a plurality of instruction values and transmits the plurality of instruction values to the drive source,

10 wherein the plurality of actuators comprise a plurality of piezoelectric elements,

the drive source comprises a drive-voltage application device including a power supply unit and a voltage controller,

the power supply unit is configured to apply voltages to the plurality of piezoelectric elements independently,

15 the operation controller is configured to determine a plurality of instruction values of the voltages to be applied to the plurality of piezoelectric elements,

the polishing head further includes a plurality of pressing members coupled to the plurality of piezoelectric elements, respectively,

20 the plurality of pressing members has a plurality of first surfaces facing the plurality of piezoelectric elements, respectively, and a plurality of second surfaces for pressing the workpiece, and

the plurality of piezoelectric elements are located between the elastic sheet and the plurality of pressing members.

25 12. The polishing head system according to any one of claims 1 to 11, wherein the polishing head further includes a plurality of pressing-force measuring devices configured to measure pressing forces generated by the plurality of piezoelectric elements, respectively.

13. The polishing head system according to claim 12, wherein the plurality of pressing-force measuring devices are arranged between the plurality of piezoelectric elements and the plurality of pressing members.

5 14. The polishing head system according to claim 12 or 13, wherein the plurality of pressing-force measuring devices are a plurality of piezoelectric sensors.

15. The polishing head system according to any one of claims 1 to 14, wherein the polishing head further includes a voltage distributor electrically coupled to the drive-voltage application device and the plurality of piezoelectric elements, the voltage distributor being
10 configured to distribute the voltage applied from the drive-voltage application device to the plurality of piezoelectric elements.

16. The polishing head system according to claim 15, wherein the voltage
15 distributor has a branch device configured to distribute the voltage applied from the drive-voltage application device to the plurality of piezoelectric elements, and a communication device coupled to the branch device and the drive-voltage application device.

17. A polishing head system for polishing a workpiece by pressing the workpiece
20 against a polishing surface while moving the workpiece and the polishing surface relative to each other in a presence of a polishing liquid, comprising:

 a polishing head having a plurality of actuators configured to apply pressing forces to a plurality of regions of the workpiece;

 a drive source configured to operate the plurality of actuators; and

25 an operation controller configured to determine a plurality of instruction values and transmits the plurality of instruction values to the drive source,

 wherein the plurality of actuators comprise a plurality of piezoelectric elements,

 the drive source comprises a drive-voltage application device including a power

supply unit and a voltage controller,

the power supply unit is configured to apply voltages to the plurality of piezoelectric elements independently,

the operation controller is configured to determine a plurality of instruction values
5 of the voltages to be applied to the plurality of piezoelectric elements,

the polishing head further includes a voltage distributor electrically coupled to the drive-voltage application device and the plurality of piezoelectric elements, the voltage distributor being configured to distribute the voltage applied from the drive-voltage application device to the plurality of piezoelectric elements,

10 the voltage distributor has a branch device configured to distribute the voltage applied from the drive-voltage application device to the plurality of piezoelectric elements, and a communication device coupled to the branch device and the drive-voltage application device, and

the voltage distributor further has a plurality of plungers contacting the plurality of
15 piezoelectric elements, and power distribution wires electrically coupling the plurality of plungers to the branch device.

18. The polishing head system according to any one of claims 15 to 17, wherein the voltage distributor is detachably attached to the polishing head.
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19. The polishing head system according to any one of claims 1 to 18, wherein the polishing head further includes a temperature measuring device configured to measure a temperature of the plurality of piezoelectric elements.

25 20. The polishing head system according to any one of claims 1 to 19, further comprising a vacuum line communicating with a workpiece contact surface of the polishing head.

21. The polishing head system according to any one of claims 1 to 20, wherein:
the polishing head further includes a retainer ring located outwardly of the plurality of piezoelectric elements; and
at least three workpiece chuck mechanisms fixed to the retainer ring.

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22. The polishing head system according to any one of claims 1 to 21, wherein the power supply unit is a DC power supply.

23. A polishing head system for polishing a workpiece by pressing the workpiece
10 against a polishing surface while moving the workpiece and the polishing surface relative to each other in a presence of a polishing liquid, comprising:

a polishing head having a plurality of piezoelectric elements configured to apply downward pressing forces to a plurality of regions of the workpiece, and a carrier holding the plurality of piezoelectric elements, the carrier having stepped portions which are in
15 contact with the plurality of piezoelectric elements to fix positions of the plurality of piezoelectric elements relative to the carrier, the polishing head further having a plurality of pressing members coupled to the plurality of piezoelectric elements, respectively; and the plurality of pressing members having a plurality of first surfaces facing the plurality of piezoelectric elements, respectively, a plurality of second surfaces for pressing the workpiece,
20 and a holding member holding the plurality of pressing members such that the plurality of pressing members are movable within a limited range, wherein each pressing member includes an upper protrusion, a lower protrusion, and a body portion located between the upper protrusion and the lower protrusion, the body portion having a width smaller than widths of the upper protrusion and the lower protrusion, and the holding member having a
25 supporting portion that movably supports the body portion;

a drive-voltage application device including a power supply unit and a voltage controller, the power supply unit being configured to apply voltages to the plurality of piezoelectric elements independently; and

an operation controller configured to determine a plurality of instruction values of the voltages to be applied to the plurality of piezoelectric elements and transmits the plurality of instruction values to the drive-voltage application device.

- 5 24. A polishing apparatus for a workpiece, comprising:
a polishing table configured to hold a polishing pad;
a polishing-liquid supply nozzle configured to supplying a polishing liquid to the
polishing pad; and
the polishing head system according to claim 1.

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25. The polishing apparatus according to claim 24, further comprising a film-thickness sensor configured to measure a film thickness of the workpiece, the film-thickness sensor being arranged in the polishing table.

- 15 26. The polishing apparatus according to claim 25, wherein the operation controller is configured to produce a film-thickness profile of the workpiece from measured values of the film thickness acquired by the film-thickness sensor, and to instruct the drive source to drive the plurality of actuators based on the film-thickness profile.

- 20 27. The polishing apparatus according to claim 26, wherein the operation controller is configured to determine a drive condition of the plurality of actuators based on a difference between the film-thickness profile and a target film-thickness profile, and to instruct the drive source.

- 25 28. A polishing apparatus for a workpiece, comprising:
a polishing table configured to hold a polishing pad;
a polishing-liquid supply nozzle configured to supply a polishing liquid to the
polishing pad; and

the polishing head system according to any one of claims 1 to 23.

29. The polishing apparatus according to claim 28, further comprising a film-thickness sensor configured to measure a film thickness of the workpiece, the film-thickness
5 sensor being arranged in the polishing table.

30. The polishing apparatus according to claim 29, wherein the operation controller is configured to produce a film-thickness profile of the workpiece from measured values of the film thickness acquired by the film-thickness sensor, and to determine instruction values
10 of the voltages to be applied to the plurality of piezoelectric elements based on the film-thickness profile.

31. The polishing apparatus according to claim 30, wherein the operation controller is configured to determine the instruction values of the voltages to be applied to the plurality
15 of piezoelectric elements based on a difference between the film-thickness profile and a target film-thickness profile.

32. The polishing apparatus according to any one of claims 24 to 31, further comprising a loading and unloading device configured to allow the polishing head to hold
20 the workpiece.

33. The polishing apparatus according to any one of claims 24 to 32, further comprising an orientation detector configured to detect an orientation of the workpiece in its circumferential direction.

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34. A polishing system for polishing a workpiece, comprising:
the polishing apparatus according to any one of claims 24 to 33;
a cleaning device configured to clean the workpiece after polishing of the

workpiece;

a drying device configured to dry the workpiece after cleaning of the workpiece;

and

a transport device configured to transport the workpiece between the polishing

5 apparatus, the cleaning device, and the drying device.