CLAIMS

[Claim 1] A polishing apparatus comprising:

a polishing table which supports a polishing pad;

a polishing head which polishes a substrate by pressing the substrate against a polishing surface of the polishing pad;

a pad temperature measuring device which measures a temperature of the polishing surface;

a pad temperature adjusting device which adjusts the temperature of the polishing surface; and

a control device which controls an operation of the pad temperature adjusting device based on the temperature of the polishing surface measured by the pad temperature measuring device,

wherein the pad temperature adjusting device includes a pad heater which is disposed to be separated upward from the polishing surface, and

wherein the pad heater includes a longitudinal portion which extends in a substantially radial direction of the polishing pad and an injection port which is slit-shaped and formed in a longitudinal direction of the longitudinal portion and injects a heating fluid toward the polishing surface,

wherein the pad temperature adjusting device further includes a shutter mechanism which adjusts an opening degree of the injection port,

wherein the shutter mechanism includes piezo elements arranged in a longitudinal direction of the injection port of the pad heater.

[Claim 2] The polishing apparatus according to claim 1,

wherein the pad temperature adjusting device further includes a vertical movement mechanism which moves the pad heater upward and downward with respect to the polishing surface.

[Claim 3] The polishing apparatus according to claim 1 or 2,

wherein the pad temperature adjusting device further includes a rotating mechanism which rotates the pad heater in a horizontal direction with respect to the polishing surface.

[Claim 4] The polishing apparatus according to any one of claims 1 to 3,

wherein the pad temperature adjusting device further includes a rotation mechanism which rotates the pad heater about a longitudinal axis of the pad heater.

[Claim 5] The polishing apparatus according to claim 1,

wherein the control device adjusts an expansion and contraction amount of each piezo element based on the temperature profile.

[Claim 6] The polishing apparatus according to any one of claims 1 to 5,

wherein the pad temperature adjusting device further includes a cooling mechanism which injects a cooling fluid to the polishing surface and cools the polishing surface.

[Claim 7] The polishing apparatus according to claim 6,

wherein the cooling mechanism includes a pad cooler which is disposed to be separated upward from the polishing surface, and

wherein the pad temperature adjusting device further includes a rotation mechanism which rotates the pad cooler about a longitudinal axis of the pad cooler.

[Claim 8] The polishing apparatus according to claim 6 or 7,

wherein the cooling mechanism includes the pad cooler which is disposed to be separated upward from the polishing surface,

wherein the pad cooler includes a longitudinal portion which extends in a substantially radial direction of the polishing pad and a plurality of injection ports which is arranged in a longitudinal direction of the longitudinal portion and injects the cooling fluid toward the polishing surface, and

wherein the cooling mechanism further includes a shutter mechanism which adjusts an opening degree of a plurality of injection ports of the pad cooler.

[Claim 9] The polishing apparatus according to any one of claims 7 to 9,

wherein the cooling mechanism includes the pad cooler which is disposed to be separated upward from the polishing surface, and

wherein the cooling mechanism further includes a guide plate which is attached to the

pad cooler and an actuator which rotates the guide plate.

[Claim 10] The polishing apparatus according to any one of claims 1 to 9,

wherein the pad temperature adjusting device further includes a suction mechanism which is disposed above the polishing surface and sucks air above the polishing surface.

[Claim 11] The polishing apparatus according to any one of claims 1 to 10,

wherein the pad temperature adjusting device further includes a heater which is disposed in the pad heater.

[Claim 12] The polishing apparatus according to any one of claims 1 to 11,

wherein the polishing table is disposed in a polishing chamber, and

wherein the pad temperature adjusting device further includes a polishing chamber suction device which sucks air in the polishing chamber so that a pressure in the polishing chamber is maintained at a predetermined value.

[Claim 13] The polishing apparatus according to any one of claims 1 to 12, further comprising:

a cleaning device which cleans the pad heater at a retreat position on a side of the polishing pad.

[Claim 14] The polishing apparatus according to any one of claims 1 to 13,

wherein the heating fluid is superheated steam.

[Claim 15] The polishing apparatus according to any one of claims 1 to 14,

wherein the control device executes a pad temperature adjustment start operation when starting surface temperature control of the polishing pad, and

wherein the pad temperature adjustment start operation is an operation of supplying the heating fluid having a flow rate and/or a temperature larger than a flow rate and/or a temperature of the heating fluid calculated so that the temperature of the polishing surface reaches a target temperature to the pad heater.

[Claim 16] The polishing apparatus according to claim 15,

wherein the pad temperature adjusting device further includes a heating fluid supply line which supplies the heating fluid to the pad heater and a flow rate regulator which is disposed in the heating fluid supply line, and

wherein the control device increases a flow rate of the heating fluid using the flow rate regulator during the pad temperature adjustment start operation.

[Claim 17] The polishing apparatus according to claim 15 or 16,

wherein the control device ends the pad temperature adjustment start operation when the temperature of the polishing surface of the polishing pad reaches the target temperature.

[Claim 18] A polishing method of polishing a substrate by pressing the substrate against a polishing surface of a polishing pad while adjusting a temperature of the polishing surface using a pad heater disposed to be separated upward from the polishing surface,

wherein when starting temperature control of the polishing surface, a pad temperature adjustment start operation is executed so that the temperature of the polishing surface reaches a target temperature,

wherein the temperature of the polishing surface is maintained at the target temperature by injecting a heating fluid from an injection port which is slit-shaped and formed in a longitudinal portion of the pad heater based on the temperature of the polishing surface measured by a pad temperature measuring device measuring the temperature of the polishing surface during polishing of the substrate, and

wherein the pad temperature adjustment start operation is an operation of supplying the heating fluid having a flow rate and/or a temperature larger than a flow rate and/or a temperature of the heating fluid calculated so that the temperature of the polishing surface reaches the target temperature to the pad heater,

wherein a step of maintaining the temperature of the polishing surface at the target temperature is executed by at least one of an operation of adjusting the temperature and/or the flow rate of the heating fluid, an operation of adjusting a vertical movement of the pad heater with respect to the polishing surface, an operation of adjusting a rotation operation

in a horizontal direction of the pad heater with respect to the polishing surface, and an operation of adjusting a rotation operation of rotating the pad heater about a longitudinal axis of the pad heater,

wherein the flow rate of the heating fluid is adjusted by a shutter capable of adjusting an opening degree of the injection port of the pad heater,

wherein the pad temperature measuring device is a measuring device capable of measuring a temperature profile in a radial direction of the polishing pad,

wherein the shutter includes piezo elements arranged in a longitudinal direction of the injection port of the pad heater, and

wherein the flow rate of the heating fluid is adjusted by adjusting an expansion and contraction amount of each piezo element based on the temperature profile.

[Claim 19] The polishing method according to claim 18,

wherein a step of maintaining the temperature of the polishing surface at the target temperature is executed by the pad heater and a cooling mechanism for cooling the polishing surface by injecting a cooling fluid to the polishing surface.

[Claim 20] The polishing method according to claim 19,

wherein the cooling mechanism includes a pad cooler which is disposed to be separated upward from the polishing surface,

wherein the pad cooler includes a longitudinal portion which extends in a substantially radial direction of the polishing pad and a plurality of injection ports which is arranged in a longitudinal direction of the longitudinal portion and injects the cooling fluid toward the polishing surface, and

wherein a step of maintaining the temperature of the polishing surface at the target temperature is executed by further adding at least one of an operation of adjusting a rotation operation of rotating the pad cooler about a longitudinal axis of the pad cooler, an operation of adjusting an opening degree of the plurality of injection ports of the pad cooler by a shutter, and an operation of adjusting a rotation operation of a guide plate attached to the pad cooler.

[Claim 21] The polishing method according to any one of claims 18 to 20,

wherein the pad temperature adjustment start operation is an operation of increasing the flow rate of the heating fluid using a flow rate regulator disposed in a heating fluid supply line supplying the heating fluid to the pad heater.

[Claim 22] The polishing method according to any one of claims 18 to 21,

wherein when the temperature of the polishing surface of the polishing pad reaches the target temperature, the pad temperature adjustment start operation is ended.