CLAIMS

[Claim 1] A chemical mechanical polishing system comprising:

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

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

a slurry supply nozzle configured to supply slurry onto the polishing surface; and

an arithmetic system having a memory storing therein a simulation model including at least a physical model configured to output an estimated polishing physical quantity including an estimated polishing rate of the workpiece, the arithmetic system being configured to

input polishing conditions for the workpiece into the simulation model;

output the estimated polishing physical quantity of the workpiece from the simulation model; and

determine model parameters of the simulation model that bring the estimated polishing physical quantity closer to a measured polishing physical quantity of the workpiece,

wherein the physical model includes a polishing-rate model configured to calculate the estimated polishing rate of the workpiece, and a polishing-torque model configured to calculate an estimated value of torque generated due to a sliding resistance of the polishing pad, and

wherein the polishing-torque model includes a head rotation torque model configured to calculate an estimated value of a polishing-head rotation torque for rotating the polishing head and the workpiece on the polishing pad about an axis of the polishing head, and a pad rotation torque model configured to calculate an estimated value of a polishing-pad rotation torque for rotating the polishing pad about an axis of the polishing pad.

~~[Claim 2] The chemical mechanical polishing system according to claim 1,~~

~~wherein the physical model includes a polishing-rate model configured to calculate the estimated polishing rate of the workpiece, and a polishing-torque model configured to calculate an estimated value of torque generated due to a sliding resistance of the polishing pad.~~

~~[Claim 3] The chemical mechanical polishing system according to claim 2, wherein the polishing-torque model includes a head rotation torque model configured to calculate an estimated value of a polishing head rotation torque for rotating the polishing head and the workpiece on the polishing pad about an axis of the polishing head, and a pad rotation torque model configured to calculate an estimated value of a polishing-pad rotation torque for rotating the polishing pad about an axis of the polishing pad.~~

[Claim 2 ~~4~~] The chemical mechanical polishing system according to claim 1 ~~3~~, further comprising a dresser configured to dress the polishing surface,

wherein the polishing-torque model includes a dresser rotation torque model configured to calculate an estimated value of a dresser rotation torque for rotating the dresser on the polishing pad about an axis of the dresser, and a dresser oscillation torque model configured to calculate an estimated value of the dresser oscillation torque around an oscillation axis required for the dresser to oscillate on the polishing pad.

[Claim 3 ~~5~~] The chemical mechanical polishing system according to claim 1 or 2 ~~any one of claims 1 to 4~~, wherein the simulation model further includes a mathematical model representing a deterioration of the polishing pad with a passage of a polishing time.

[Claim 4 ~~6~~] The chemical mechanical polishing system according to any one of claims 1 to 3 ~~5~~, wherein the arithmetic system is configured to:

input the polishing conditions to the simulation model having the determined model parameters to calculate an updated estimated polishing physical quantity; and

evaluate a difference between the updated estimated polishing physical quantity and the measured polishing physical quantity.

[Claim 5] The chemical mechanical polishing system according to any one of claims 1 to 4, wherein the arithmetic system is configured to calculate a distribution of coefficient of friction of the workpiece.

[Claim 6] The chemical mechanical polishing system according to any one of claims 1 to 5, wherein the arithmetic system is configured to determine the model parameters using at least one of a least square method, a steepest descent method, and a simplex method.

[Claim 7] The chemical mechanical polishing system according to any one of claims 1 to 6, wherein the polishing-torque model further includes a head oscillation torque model configured to calculate an estimated value of a polishing-head oscillation torque around an oscillation axis of the polishing head required for the polishing head to oscillate on the polishing pad.

[Claim 8] A chemical mechanical polishing system comprising:

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

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

a slurry supply nozzle configured to supply slurry onto the polishing surface; and

an arithmetic system having a memory storing therein a simulation model including at least a physical model configured to output an estimated polishing physical quantity including an estimated polishing rate of the workpiece, the arithmetic system being configured to

input polishing conditions for the workpiece into the simulation model;

output the estimated polishing physical quantity of the workpiece from the simulation model; and

determine model parameters of the simulation model that bring the estimated polishing physical quantity closer to a measured polishing physical quantity of the workpiece,

wherein the physical model includes a polishing-rate model configured to calculate the estimated polishing rate of the workpiece, and a polishing-torque model configured to calculate an estimated value of torque generated due to a sliding resistance of the polishing pad, and

wherein the polishing-torque model includes a head oscillation torque model configured to calculate an estimated value of a polishing-head oscillation torque around an oscillation axis of the polishing head required for the polishing head to oscillate on the polishing pad, and a pad rotation torque model configured to calculate an estimated value of a polishing-pad rotation torque for rotating the polishing pad about an axis of the polishing pad.

[Claim 9 ~~7~~] An arithmetic system for creating a simulation model for chemical mechanical polishing, comprising:

a memory storing a program and the simulation model therein;

a processor configured to perform operations according to instructions included in the program,

wherein the simulation model includes at least a physical model configured to output an estimated polishing physical quantity including an estimated polishing rate of a workpiece when chemically mechanically polished, the arithmetic system being configured to

input polishing conditions for the workpiece into the simulation model;

output the estimated polishing physical quantity of the workpiece from the simulation model; and

determine model parameters of the simulation model that bring the estimated polishing physical quantity closer to a measured polishing physical quantity of the workpiece,

wherein the physical model includes a polishing-rate model configured to calculate the estimated polishing rate of the workpiece, and a polishing-torque model configured to calculate an estimated value of torque generated due to a sliding resistance of a polishing pad against which the workpiece is pressed by a polishing head, and

wherein the polishing-torque model includes a head rotation torque model configured to calculate an estimated value of a polishing-head rotation torque for rotating the polishing head and the workpiece on the polishing pad about an axis of the polishing head, and a pad rotation torque model configured to calculate an estimated value of a polishing-pad rotation torque for rotating the polishing pad about an axis of the polishing pad.

[Claim 10 ~~8~~] A method of producing a simulation model for chemical mechanical polishing, comprising:

inputting polishing conditions for a workpiece into the simulation model, the simulation model including at least a physical model configured to output an estimated polishing physical quantity including an estimated polishing rate of the workpiece;

outputting the estimated polishing physical quantity of the workpiece from the simulation model;

polishing the workpiece using a polishing apparatus; and

determining model parameters of the simulation model that bring the estimated polishing physical quantity closer to a measured polishing physical quantity of the workpiece,

wherein the polishing apparatus includes:

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

a slurry supply nozzle configured to supply slurry onto the polishing surface,

wherein the physical model includes a polishing-rate model configured to calculate the estimated polishing rate of the workpiece, and a polishing-torque model configured to calculate an estimated value of torque generated due to a sliding resistance of the polishing pad, and

wherein the polishing-torque model includes a head rotation torque model configured to calculate an estimated value of a polishing-head rotation torque for rotating the polishing head and the workpiece on the polishing pad about an axis of the polishing head, and a pad rotation torque model configured to calculate an estimated value of a polishing-pad rotation torque for rotating the polishing pad about an axis of the polishing pad.

~~[Claim 9] The method according to claim 8, wherein the physical model includes a polishing-rate model configured to calculate the estimated polishing rate of the workpiece, and a polishing-torque model configured to calculate an estimated value of torque generated due to a sliding resistance of the polishing pad.~~

~~[Claim 10] The method according to claim 9, wherein the polishing-torque model includes a head rotation torque model configured to calculate an estimated value of a polishing-head rotation torque for rotating the polishing head and the workpiece on the polishing pad about an axis of the polishing head, and a pad rotation torque model configured to calculate an estimated value of a polishing-pad rotation torque for rotating the polishing pad about an axis of the polishing pad.~~

[Claim 11] The method according to claim 10, wherein the polishing apparatus further includes a dresser configured to dress the polishing surface,

wherein the polishing-torque model includes a dresser rotation torque model configured to calculate an estimated value of a dresser rotation torque for rotating the dresser on the polishing pad about an axis of the dresser, and a dresser oscillation torque model configured to calculate an estimated value of the dresser oscillation torque around an oscillation axis required for the dresser to oscillate on the polishing pad.

[Claim 12] The method according to claim 10 or 11 ~~any one of claims 8 to 11~~, wherein the simulation model further includes a mathematical model representing a deterioration of the polishing pad with a passage of a polishing time.

[Claim 13] The method according to any one of claims 10 ~~8~~ to 12, further comprising:

inputting the polishing conditions to the simulation model having the determined model parameters to calculate an updated estimated polishing physical quantity; and

evaluating a difference between the updated estimated polishing physical quantity and the measured polishing physical quantity.

[Claim 14] A method of producing a simulation model for chemical mechanical polishing, comprising:

inputting polishing conditions for a workpiece into the simulation model, the simulation model including at least a physical model configured to output an estimated polishing physical quantity including an estimated polishing rate of the workpiece;

outputting the estimated polishing physical quantity of the workpiece from the simulation model; and

determining model parameters of the simulation model that bring the estimated polishing physical quantity closer to a measured polishing physical quantity of the workpiece,

wherein the physical model includes a polishing-rate model configured to

calculate the estimated polishing rate of the workpiece, and a polishing-torque model configured to calculate an estimated value of torque generated due to a sliding resistance of a polishing pad against which the workpiece is pressed by a polishing head, and

wherein the polishing-torque model includes a head rotation torque model configured to calculate an estimated value of a polishing-head rotation torque for rotating the polishing head and the workpiece on the polishing pad about an axis of the polishing head, and a pad rotation torque model configured to calculate an estimated value of a polishing-pad rotation torque for rotating the polishing pad about an axis of the polishing pad.