CLAIMS

1. A method, comprising:

performing a plurality of substrate processing operations on a plurality of substrates in a process chamber, wherein one of the plurality of substrates is processed during each of the plurality of substrate processing operations;

determining a substrate temperature change of each of the plurality of substrates during the plurality of substrate processing operations;

inputting measured process variables into a substrate temperature change model based on the substrate temperature of each of the plurality of substrates, the substrate temperature change model comprising:

$$\Delta T_i = \int_{W_1}^{W_2} \frac{dT_i}{dW} dW$$

$$\Delta T_o = \int_{W_1}^{W_2} \frac{dT_o}{dW} dW$$

where W_1 is a first substrate count for a first substrate, W_2 is a second substrate count for the first substrate, ΔT_i and ΔT_o are a total change in temperature of inner and outer zones, respectively, from W_1 to W_2, and $\frac{dT_i}{dW}$ and $\frac{dT_o}{dW}$ are a rate of change of inner zone temperature and outer zone temperature, respectively; and

controlling one or more of temperature or power setpoints of a heater apparatus in a substrate support of the process chamber in response to an output of the substrate temperature change model.

2. The method of claim 1, wherein the heater apparatus is a resistive heater.

3. The method of claim 1, wherein the determining a substrate temperature of each of the plurality of substrates further comprises:

measuring a temperature-dependent film property of a film deposited on each of the plurality of substrates during the plurality of substrate processing operations; and

determining the substrate temperature of each of the plurality of substrates based on the temperature-dependent film property.

4. The method of claim 3, wherein the temperature-dependent film property is an optical absorption coefficient.

5. The method of claim 3, wherein the film is a carbon hardmask.

6. The method of claim 1, wherein the determining a substrate temperature of each of the plurality of substrates further comprises:

measuring a power output of the heater apparatus during each of a plurality of time intervals during each of the plurality of substrate processing operations; and

determining the substrate temperature of each of the plurality of substrates based on the power output during each of the plurality of time intervals.

7. The method of claim 6, wherein the power output is measured using a power meter.

8. A method, comprising:

performing a plurality of substrate processing operations on a plurality of substrates in a process chamber, wherein one of the plurality of substrates is processed during each of the plurality of substrate processing operations;

determining a temperature of an inner zone of each of the plurality of substrates during the plurality of substrate processing operations, comprising:

measuring a power output of the heater apparatus corresponding to the inner zone of the substrate during each of a plurality of time intervals during each of the plurality of substrate processing operations; and

determining the inner zone temperature of each of the plurality of substrates based on the power output during each of the plurality of time intervals;

determining a temperature of an outer zone of each of the plurality of substrates during the plurality of substrate processing operations;

determining an inner zone temperature model based on the temperature of the inner zone of each of the plurality of substrates;

determining an outer zone temperature model based on the temperature of the outer zone of each of the plurality of substrates;

controlling an inner zone setpoint of a heater apparatus in a substrate support of the process chamber based on the inner zone temperature model; and

controlling an outer zone setpoint of the heater apparatus in the substrate support of the process chamber based on the outer zone temperature model.

9. The method of claim 8, wherein the heater apparatus is a resistive heater.

10. The method of claim 8, wherein the determining an inner zone temperature of each of the plurality of substrates further comprises:

measuring a temperature-dependent film property in the inner zone of the substrate of a film deposited on each of the plurality of substrates during the plurality of substrate processing operations; and

determining the inner zone temperature of each of the plurality of substrates based on the temperature-dependent film property.

11. The method of claim 8, wherein the determining an outer zone temperature of each of the plurality of substrates further comprises:

measuring a temperature-dependent film property in the outer zone of the substrate of a film deposited on each of the plurality of substrates during the plurality of substrate processing operations; and

determining the outer zone temperature of each of the plurality of substrates based on the temperature-dependent film property.

12. The method of claim 10, wherein the temperature-dependent film property is an optical absorption coefficient.

13. The method of claim 11, wherein the temperature-dependent film property is an optical absorption coefficient.

14. The method of claim 10, wherein the film is a carbon hardmask.

15. The method of claim 11, wherein the film is a carbon hardmask.

16. A method, comprising:

performing a plurality of substrate processing operations on a plurality of substrates in a process chamber, wherein one of the plurality of substrates is processed during each of the plurality of substrate processing operations;

determining a temperature of an inner zone of each of the plurality of substrates during the plurality of substrate processing operations;

determining a temperature of an outer zone of each of the plurality of substrates during the plurality of substrate processing operations, comprising:

measuring a power output of the heater apparatus corresponding to the outer zone of the substrate during each of a plurality of time intervals during each of the plurality of substrate processing operations; and

determining the outer zone temperature of each of the plurality of substrates based on the power output during each of the plurality of time intervals;

determining an inner zone temperature model based on the temperature of the inner zone of each of the plurality of substrates;

determining an outer zone temperature model based on the temperature of the outer zone of each of the plurality of substrates;

controlling an inner zone setpoint of a heater apparatus in a substrate support of the process chamber based on the inner zone temperature model; and

controlling an outer zone setpoint of the heater apparatus in the substrate support of the process chamber based on the outer zone temperature model.

17. The method of claim 8, wherein the power output is measured using a power meter.

18. The method of claim 16, wherein the power output is measured using a power meter.

19. A non-transitory machine readable storage medium having stored thereon a computer program, the computer program configured to:

determine a substrate temperature change model based on a substrate temperature of each of a plurality of substrates during each of a plurality of substrate processing operations in a process chamber;

control a setpoint of a heater apparatus in a substrate support of the process chamber based on a substrate temperature change model, the substrate temperature model comprising:

$$\Delta T_i = \int_{W_1}^{W_2} \frac{dT_i}{dW} dW$$

$$\Delta T_o = \int_{W_1}^{W_2} \frac{dT_o}{dW} dW$$

where W_1 is a first substrate count for a first substrate, W_2 is a second substrate count for the first substrate, ΔT_i and ΔT_o are a total change in temperature of inner and outer zones, respectively, from W_1 to W_2, and $\frac{dT_i}{dW}$ and $\frac{dT_o}{dW}$ are a rate of change of inner zone temperature and outer zone temperature, respectively.

20. The method of claim 16, wherein the determining an inner zone temperature of each of the plurality of substrates further comprises:

measuring a temperature-dependent film property in the inner zone of the substrate of a film deposited on each of the plurality of substrates during the plurality of substrate processing operations; and

determining the inner zone temperature of each of the plurality of substrates based on the temperature-dependent film property.

21. The method of claim 16, wherein the determining an outer zone temperature of each of the plurality of substrates further comprises:

measuring a temperature-dependent film property in the outer zone of the substrate of a film deposited on each of the plurality of substrates during the plurality of substrate processing operations; and

determining the outer zone temperature of each of the plurality of substrates based on the temperature-dependent film property.