CLAIMS

What is claimed is:

1. A method of dynamically calibrating a heater having a plurality of zones defined by one or more resistive heating elements, the method comprising:

controlling power to the plurality of zones based on a dynamic resistance-temperature (R-T) model to control a temperature of the heater to a temperature setpoint;

for each of the plurality of zones,

measuring a temperature of a respective zone based on a resistance of the one or more resistive heating elements of the respective zone and the dynamic R-T model;

measuring, by a reference sensor, a reference temperature for the respective zone;

determining whether the temperature and the reference temperature are equal;

in response to the temperature and the reference temperature not being equal, incrementally adjusting a resistance value associated with the temperature setpoint provided in the dynamic R-T model for the respective zone; and

providing the resistance value as a calibrated resistance value when the temperature of the respective zone and the reference temperature are equal; and

providing the dynamic R-T model that correlates the calibrated resistance values of the plurality of zones with the temperature setpoint as a calibrated R-T model.

2. The method of Claim 1, wherein controlling the power to the heater further comprises:

measuring resistances of the resistive heating elements;

determining the temperature of each of the plurality of zones based on the resistance for the respective zone and the dynamic R-T model; and

adjusting the power to the respective zone in response to the temperature of the respective zone being different from the temperature setpoint until the temperature of the respective zone is equal to the temperature setpoint.

3. The method of Claim 2, wherein when the temperature of each of the plurality of zones equals the temperature setpoint, the method further comprises applying a voltage pulse to the plurality of zones and measuring a thermal response of the plurality of zones.

4. The method of Claim 2, wherein when the temperature of each of the plurality of zones equals the temperature setpoint, the method further comprises adjusting an external system variable and measuring a thermal response of the plurality of zones, wherein the external system variable includes chamber pressures, backside gas pressures, gas flow rates, an emissivity of a chamber, an emissivity of a pedestal, or a combination thereof.

5. The method of Claim 1, wherein incrementally adjusting resistance values further comprises, for the respective zone, determining a resistance adjustment rate based on a predefined gain factor and a difference between the reference temperature associated with the respective zone and the temperature of the respective zone.

6. The method of Claim 1, wherein incrementally adjusting resistance values further comprises:

decreasing a resistance value associated with the respective zone when the reference temperature of the respective zone is greater than the temperature of the respective zone; and

increasing the resistance value associated with the respective zone when the reference temperature of the respective zone is less than the temperature of the respective zone.

7. The method of Claim 1 further comprising:

applying a nominal measurement voltage to each of the plurality of zones; and

measuring a cold start resistance for each of the plurality of zones prior to controlling the temperature of the heater to the temperature setpoint.

8. The method of Claim 1, wherein:

the temperature setpoint is selected from among a plurality of temperature setpoints and the calibrated resistance values for each of the zones is determined for each of the plurality of temperature setpoints, and

the dynamic R-T model provides, for each of the plurality of temperature setpoints, the calibrated resistance values for each of the plurality of zones.

9. The method of Claim 1 further comprising thermally leveling the reference temperatures of the plurality of zones such that the reference temperature for a first zone is substantially the same as that of a second zone that is associated with the first zone.

10. The method of Claim 1 further comprising, for each of the zones:

determining whether the temperature of the respective zone is equal to the reference temperature of the respective zone, wherein the resistance value is incrementally adjusted in response to the temperature not equaling the reference temperature; and

storing the resistance value as the calibrated resistance value for the respective zone in response to the temperature of the respective zone equaling the reference temperature.

11. The method of Claim 1, further comprising:

storing the calibrated R-T model in response to the calibrated resistance values being provided for each of the plurality of zones.

12. The method of Claim 11 further comprising thermally leveling the reference temperatures of the plurality of zones such that the reference temperature for a first zone is substantially the same as that of a second zone associated with the first zone.

13. The method of Claim 12, wherein the resistance value is stored in the dynamic R-T model as the calibrated resistance value for the temperature setpoint in response to the zone temperature equaling the reference temperature and the plurality of reference temperatures being thermally leveled.

14. The method of Claim 11, wherein:

the temperature setpoint is selected from among a plurality of temperature setpoints, and the calibrated resistance value is determined for each of the plurality of temperature setpoints, and

the dynamic R-T model provides, for each of the plurality of temperature setpoints, the calibrated resistance values for each of the plurality of zones.

15. The method of Claim 11, wherein incrementally adjusting resistance values further comprises determining a resistance adjustment rate based on a predefined gain factor and a difference between the reference temperature and the zone temperature of the respective zone.

16. The method of Claim 11, wherein incrementally adjusting the resistance value for the respective zone further comprises:

decreasing a resistance value associated with the respective zone when the reference temperature of the respective zone is greater than the temperature of the respective zone; and

increasing the resistance value associated with the respective zone when the reference temperature of the respective zone is less than the temperature of the respective zone.

17. A control system for controlling power to a heater having a plurality of zones, each of the plurality of zones being defined by one or more resistive heating elements, the control system comprising:

a controller configured to control power to the heater and determine a temperature of each of the plurality of zones based on a calibrated resistance-temperature (R-T) model, the controller being configured to execute a dynamic calibration process to define the calibrated R-T model, wherein the dynamic calibration process comprises:

performing, using a dynamic R-T model, a closed-loop temperature control to maintain temperature of the heater to a temperature setpoint;

for each of the plurality of zones,

obtaining a reference temperature for a respective zone;

thermally leveling the reference temperature of the respective zone with one or more other reference temperatures by adjusting the resistive value associated with the respective zone in response to the temperature of the heater not equaling the temperature setpoint;

measuring a zone temperature for the respective zone based on a resistance of the one or more resistive heating elements of the respective zone and the dynamic R-T model for the respective zone;

determining, for the respective zone, whether the zone temperature is equal to the reference temperature;

in response to the zone temperature not equaling the reference temperature, incrementally adjusting a resistance value associated with the temperature setpoint provided in the dynamic R-T model for the respective zone; and

in response to the zone temperature equaling the reference temperature and the reference temperature being thermally leveled, providing the resistance value in the dynamic R-T model as a calibrated resistance value for the temperature setpoint for the respective zone; and

storing the dynamic R-T model that correlates the calibrated resistance values with the temperature setpoint for the plurality of zones as the calibrated R-T model.

18. The control system of Claim 17, wherein incrementally adjusting resistance values further comprises~~,~~ determining a resistance adjustment rate based on a predefined

gain factor and a difference between the reference temperature and the zone temperature of the respective zone.

19. The control system of Claim 17, wherein incrementally adjusting the resistance value for the respective zone further comprises:

decreasing the resistance value associated with the respective zone when the reference temperature of the respective zone is greater than the temperature of the respective zone; and

increasing the resistance value associated with the respective zone when the reference temperature of the respective zone is less than the temperature of the respective zone.