Claims

1. A method for defining a plasma process to be performed on a substrate, comprising:

determining a time-dependent substrate temperature to be applied during the plasma process, wherein the time-dependent substrate temperature at any given time is determined based on control of a sticking coefficient of a plasma constituent at the given time;

determining a time-dependent temperature differential between an upper plasma boundary and a substrate to be applied during the plasma process, wherein the substrate serves as a lower plasma boundary, and wherein the time-dependent temperature differential at any given time is determined based on control of a flux of the plasma constituent directed toward the substrate at the given time;

storing the determined time-dependent substrate temperature and time-dependent temperature differential in a digital format suitable for use by a temperature control device defined and connected to direct temperature control of the upper plasma boundary and the substrate during the plasma process; and

operating the temperature control device to direct temperature control of the upper plasma boundary and the substrate during the plasma process in accordance with the determined time-dependent substrate temperature and time-dependent temperature differential between the upper plasma boundary and the substrate.

2. The method as recited in claim 1, wherein the sticking coefficient is a temperature dependent parameter that represents an affinity of the plasma constituent to adhere to the substrate.

3. The method as recited in claim 1, wherein an increase in substrate temperature corresponds to a reduced sticking coefficient representing a lower affinity of the plasma constituent to adhere to the substrate, and

wherein a decrease in substrate temperature corresponds to an increased sticking coefficient representing a higher affinity of the plasma constituent to adhere to the substrate.

4. The method as recited in claim 1, wherein the time-dependent temperature differential is defined based on a thermophoresis effect on the plasma constituent, whereby higher mass portions of the plasma constituent move toward lower temperature regions, and whereby lower mass portions of the plasma constituent move toward higher temperature regions, and wherein the movement of the plasma constituent based on its mass and regional

temperatures to which it is exposed controls the flux of the plasma constituent directed toward the substrate.

5. The method as recited in claim 1, wherein the plasma process includes a high aspect ratio feature etching process in which a number of high aspect ratio features are etched into one or more materials present on the substrate.

6. The method as recited in claim 5, wherein the time-dependent temperature differential between the upper plasma boundary and the substrate is set during the high aspect ratio feature etching process to ensure that the flux of the plasma constituent toward the substrate provides sufficient amounts of appropriate masses of the plasma constituent near the substrate and within the number of high aspect ratio features.

7. The method as recited in claim 6, wherein the time-dependent substrate temperature is set during the high aspect ratio feature etching process to ensure that a sufficient amount of the plasma constituent adheres to a mask on the substrate so as to preserve the mask through completion of the plasma process, and to ensure that a sufficient amount of the plasma constituent adheres to sidewalls of the number of high aspect ratio features to protect the sidewalls from being adversely undercut, and to ensure that the number of high aspect ratio features remain open through completion of the plasma process.

8. The method as recited in claim 1, wherein the plasma constituent is a polymer that is resistant to etching capabilities of the plasma process.

9. The method as recited in claim 1, further comprising:

determining a time-dependent substrate support temperature necessary to achieve the determined time-dependent substrate temperature, wherein the substrate is held in thermal contact with the substrate support during the plasma process; and

storing the determined time-dependent substrate support temperature in a digital format suitable for use by a temperature control device defined and connected to direct temperature control of the substrate support during the plasma process.

10. The method as recited in claim 1, wherein each of the time-dependent substrate temperature and the time-dependent temperature differential between the upper plasma boundary and the substrate is defined as a function of radial position extending from a center

of the substrate to a periphery of the substrate.

11. A method for controlling temperature during plasma processing of a substrate, comprising:

receiving substrate holder temperature measurements from a first temperature measurement device disposed to measure a temperature of a substrate holder;

receiving upper electrode assembly temperature measurements from a second temperature measurement device disposed to measure a temperature of an upper electrode assembly;

receiving data defining a prescribed time-dependent temperature of a substrate from a data storage module;

receiving data defining a prescribed time-dependent temperature differential between the upper electrode assembly and the substrate from the data storage module, wherein the prescribed time-dependent temperature differential between the upper electrode assembly and the substrate at a given time is correlated to control of a flux of a plasma constituent toward the substrate at the given time;

processing the received substrate holder temperature measurements and the received upper electrode assembly temperature measurements to generate control signals for one or more temperature control devices of the substrate holder and for one or more temperature control devices of the upper electrode assembly so as to follow both the prescribed time-dependent temperature of the substrate and the prescribed time-dependent temperature differential between the upper electrode assembly and the substrate;

transmitting the generated control signals to the one or more temperature control devices of the substrate holder and to the one or more temperature control devices of the upper electrode assembly; and

operating the one or more temperature control devices of the substrate holder and the one or more temperature control devices of the upper electrode assembly in accordance with the generated control signals.

12. The method as recited in claim 11, wherein processing the received substrate holder temperature measurements and the received upper electrode assembly temperature measurements to generate control signals for one or more temperature control devices of the substrate holder and for one or more temperature control devices of the upper electrode assembly includes correlating the received substrate holder temperature measurements to corresponding substrate temperature measurements.

13. The method as recited in claim 11, wherein the prescribed time-dependent temperature of the substrate at the given time is correlated to control of a sticking coefficient of a plasma constituent at the given time.

14. The method as recited in claim 11, wherein the prescribed time-dependent temperature of the substrate is defined as a function of radial position extending from a center of the substrate to a periphery of the substrate, and wherein the prescribed time-dependent temperature differential between the upper electrode assembly and the substrate is defined as the function of radial position extending from the center of the substrate to the periphery of the substrate.

15. The method as recited in claim 11, further comprising:

increasing the temperature of the substrate to cause a reduction in an amount of a plasma constituent adhering to the substrate.

16. The method as recited in claim 11, further comprising:

decreasing the temperature of the substrate to cause an increase in an amount of a plasma constituent adhering to the substrate.

17. The method as recited in claim 11, further comprising:

receiving substrate holder temperature measurements from multiple temperature measurement devices disposed to measure temperatures of a substrate holder in corresponding multiple concentric regions of the substrate holder;

receiving upper electrode assembly temperature measurements from multiple temperature measurement devices disposed to measure a temperature of an upper electrode assembly in corresponding multiple concentric regions of the upper electrode assembly;

receiving data defining prescribed time-dependent temperatures for multiple concentric regions of a substrate from a data storage module;

receiving data defining prescribed time-dependent temperature differentials between the upper electrode assembly and the substrate for multiple concentric regions of the substrate from the data storage module; and

processing the received substrate holder temperature measurements and the received upper electrode assembly temperature measurements to generate the control signals for the one or more temperature control devices of the substrate holder and for the one or more

temperature control devices of the upper electrode assembly so as to follow the prescribed time-dependent temperatures for each of the multiple concentric regions of the substrate and so as to follow the prescribed time-dependent temperature differentials between the upper electrode assembly and the substrate for each of the multiple concentric regions of the substrate.

18. The method as recited in claim 11, further comprising:

receiving peripheral shroud assembly temperature measurements from at least one temperature measurement device disposed to measure a temperature of a peripheral shroud assembly;

receiving data defining a prescribed time-dependent temperature of the peripheral shroud assembly;

processing the received peripheral shroud assembly temperature measurements to generate additional control signals for the at least one temperature control device of the peripheral shroud assembly;

transmitting the generated additional control signals to the at least one temperature control device of the peripheral shroud assembly; and

operating the at least one temperature control devices of the peripheral shroud assembly in accordance with the generated additional control signals.

19. The method as recited in claim 18, wherein the peripheral shroud assembly is disposed between the upper electrode assembly and the substrate holder, and wherein the peripheral shroud assembly forms a peripheral boundary of a plasma generation volume between the upper electrode assembly and the substrate holder.