

WHAT IS CLAIMED IS CLAIMS:

1. A plasma processing apparatus for processing semiconductor substrates, comprising:
 a plasma processing chamber in which a semiconductor substrate is processed;
 a process gas source in fluid communication with the plasma processing chamber adapted to supply process gas into the plasma processing chamber;
 a RF energy source adapted to energize the process gas into a plasma state in the plasma processing chamber;
 a vacuum source adapted to exhaust process gas and byproducts of the plasma processing from the plasma processing chamber; and
 at least one component comprising a laterally extending optical fiber beneath a plasma exposed surface of the component wherein spatial temperature measurements of the surface are desired to be taken, and a temperature monitoring arrangement coupled to the optical fiber so as to monitor temperatures at different locations along the optical fiber,
wherein the temperature monitoring arrangement is a sensor system coupled to the optical fiber wherein the sensor system includes a light source and a detector, the light source operable to provide near infrared, infrared, natural, or ultraviolet light into the optical fiber and the detector operable to measure light exiting the optical fiber wherein the sensor system can determine temperatures at different locations along the optical fiber based on the parameters of the light entering and exiting the optical fiber.

2. ~~The plasma processing apparatus of Claim 1, wherein the temperature monitoring arrangement is a sensor system coupled to the optical fiber wherein the sensor system includes a light source and a detector, the light source operable to provide near infrared, infrared, natural, or ultraviolet light into the optical fiber and the detector operable to measure light exiting the optical fiber wherein the sensor system can determine temperatures at different locations along the optical fiber based on the parameters of the light entering and exiting the optical fiber.~~

~~32~~. The plasma processing apparatus of Claim 1, further comprising at least one of (a)-(d), wherein:

(a) an adhesive wherein the adhesive bonds the optical fiber to walls of a channel in the component;

(b) a control system configured to control processes performed by at least one of the plasma processing apparatus and ~~or~~ the temperature monitoring arrangement;

(c) a non-transitory computer machine-readable medium comprising program instructions for control of the temperature monitoring arrangement; and ~~or~~

(d) one or more laterally extending optical fibers beneath the plasma exposed surface of the component wherein spatial temperature measurements of the surface are desired to be taken wherein each optical fiber is configured to be coupled to the temperature monitoring arrangement so as to monitor temperatures at different locations of each optical fiber wherein the one or more laterally extending optical fibers are each configured to be beneath a respective portion of the plasma exposed surface wherein spatial temperature measurements are desired to be taken and the one or more laterally extending optical fibers are in a single channel of the component or at least two respective channels of the component wherein each channel ~~(a)~~ includes one or more curves, ~~(b)~~ ii is linear, ~~(c)~~ iii is circular, ~~(d)~~ iv is semicircular, and/or v is patterned in a zig-zag pattern, a serpentine pattern, or a spiral pattern.

~~43~~. The plasma processing apparatus of Claim 1, wherein the optical fiber includes a plurality of fiber Bragg gratings along ~~the~~ a length of the optical fiber wherein each fiber Bragg grating reflects a wavelength of light indicative of a local temperature thereof or a plurality of long period gratings along the length of the optical fiber wherein each long period grating transmits a wavelength of light indicative of a local temperature thereof.

~~54~~. The plasma processing apparatus of Claim 1, wherein the component:

(a) is a heater layer of a substrate support assembly;

(b) is a thermal control plate of a showerhead electrode assembly;

- (c) is a chamber wall;
- (d) is an electrostatic chuck operable to electrostatically hold a substrate on an upper surface thereof;
- (e) is a showerhead electrode;
- (f) is a confinement ring;
- (g) is a dielectric window;
- (h) is an RF antenna; ~~and/or~~
- (i) is a thermoelectric module.

65. The plasma processing apparatus of Claim 1, wherein the laterally extending optical fiber is in a channel in the component wherein:

- (a) the channel includes one or more curves;
- (b) the channel is linear;
- (c) the channel is circular;
- (d) the channel is semicircular;
- (e) the channel is patterned in a zig-zag pattern, a serpentine pattern, or a spiral pattern;
- ~~and/or~~
- _____ (f) the channel includes an inlet wherein the inlet is in a non-exposed surface of the component or a lower surface of the component; or
- (g) the channel includes an inlet and an outlet wherein the inlet and the outlet are in a non-exposed surface of the component.

76. A component of a plasma processing apparatus comprising:
 _____ a laterally extending optical fiber beneath a plasma exposed surface of the component wherein spatial temperature measurements of the plasma exposed surface are desired to be taken, wherein the laterally extending optical fiber is configured to be coupled to a temperature monitoring arrangement such that temperatures at different locations along the optical fiber can be monitored.

wherein the temperature monitoring arrangement is a sensor system coupled to the optical fiber wherein the sensor system includes a light source and a detector, the light source operable to provide near infrared, infrared, natural, or ultraviolet light into the optical fiber and the detector operable to measure light exiting the optical fiber wherein the sensor system can determine temperatures at different locations along the optical fiber based on parameters of the light entering and exiting the optical fiber.

87. The component of Claim 76, wherein the laterally extending optical fiber is in a channel in the component wherein:

- (a) the channel includes one or more curves;
- (b) the channel is linear;
- (c) the channel is circular;
- (d) the channel is semicircular; ~~and/or~~
- (e) the channel of the component is patterned in a zig-zag pattern, a serpentine pattern, or a spiral pattern; ~~and/or~~
- (f) the channel includes an inlet wherein the inlet is in a non-exposed surface of the component; or
- (g) the channel includes an inlet and an outlet wherein the inlet and the outlet are in a non-exposed surface of the component.

98. The component of Claim 76, wherein the optical fiber includes a plurality of fiber Bragg gratings along ~~the~~ length of the optical fiber wherein each fiber Bragg grating is configured to reflect a wavelength of light indicative of a local temperature thereof or a plurality of long period gratings along the length of the optical fiber wherein each long period grating is configured to transmit a wavelength of light indicative of a local temperature thereof.

109. The component of Claim 76, further comprising at least one of (a) and (b), wherein:

(a) an adhesive wherein the adhesive bonds the optical fiber to walls of a channel in the component; and/or

(b) one or more laterally extending optical fibers beneath the plasma exposed surface of the component wherein spatial temperature measurements of the plasma exposed surface are desired to be taken wherein each optical fiber is configured to be coupled to the temperature monitoring arrangement so as to monitor temperatures at different locations of each optical fiber wherein the one or more laterally extending optical fibers are each configured to be beneath a respective portion of the plasma exposed surface wherein spatial temperature measurements are desired to be taken and the one or more laterally extending optical fibers are in a single channel of the component or at least two respective channels of the component wherein each channel (a) includes one or more curves, (b) is linear, (c) is circular, (d) is semicircular, and/or (v) is patterned in a zig-zag pattern, a serpentine pattern, or a spiral pattern.

1110. The component of Claim 76, wherein the component:

- (a) is a heater layer of a substrate support assembly;
- (b) is a thermal control plate of a showerhead electrode assembly;
- (c) is a chamber wall;
- (d) is an electrostatic chuck operable to electrostatically hold a substrate on an upper surface thereof;
- (e) is a showerhead electrode;
- (f) is a confinement ring;
- (g) is a dielectric window;
- (h) is an RF antenna; and/or
- (i) is a thermoelectric module.

1111. A substrate support assembly of a plasma processing apparatus, the substrate support assembly comprising the component of Claim 76.

~~13~~12. The substrate support assembly of Claim ~~12~~11, further comprising at least one of (a)-(d), wherein:

(a) a sensor system coupled to the optical fiber wherein the sensor system includes ~~a~~the light source and ~~a~~the detector, the light source operable to provide near infrared, infrared, natural, or ultraviolet light into the optical fiber and the detector operable to measure light exiting the optical fiber wherein the sensor system can determine temperatures at different locations along the optical fiber based on the parameters of the light entering and exiting the optical fiber;

(b) a control system configured to control processes performed by at least one of the substrate support assembly and ~~or~~ the temperature monitoring arrangement;

(c) a non-transitory computer machine-readable medium comprising program instructions for control of the temperature monitoring arrangement; and/or

~~(e)~~d one or more laterally extending optical fibers beneath the plasma exposed surface of the component wherein spatial temperature measurements of the plasma exposed surface are desired to be taken wherein each optical fiber is configured to be coupled to the temperature monitoring arrangement so as to monitor temperatures at different locations of each optical fiber wherein the one or more laterally extending optical fibers are each configured to be beneath a respective portion of the exposed surface wherein spatial temperature measurements are desired to be taken and the at least two of the laterally extending optical fibers are in a single channel of the component or at least two respective channels of the component wherein each channel ~~(a)~~i includes one or more curves, ~~(b)~~ii is linear, ~~(c)~~iii is circular, ~~(d)~~iv is semicircular, ~~and/or~~ (v) is patterned in a zig-zag pattern, a serpentine pattern, or a spiral pattern.

~~14~~13. The substrate support assembly of Claim ~~12~~11, wherein the component is at least one of (a)-(c), wherein:

(a) an electrostatic chuck;

(b) a heater layer; and ~~or~~

(c) a cooling plate.

~~15~~14. The substrate support assembly of Claim ~~12~~11, wherein the laterally extending optical fiber is in a channel in the component wherein:

- (a) the channel includes one or more curves;
- (b) the channel is linear;
- (c) the channel is circular;
- (d) the channel is semicircular; ~~and/or~~
- (e) the channel of the component is patterned in a zig-zag pattern, a serpentine pattern, or a spiral pattern; ~~and/or~~
- (f) the channel includes an inlet wherein the inlet is in a non-exposed surface of the component; or
- (g) the channel includes an inlet and an outlet wherein the inlet and the outlet are in a non-exposed surface of the component.

~~16~~15. The substrate support assembly of Claim ~~12~~11, wherein:

- (a) the substrate support assembly includes a plurality of planar heater zones wherein each planar heater zone corresponds to a respective device die location of a semiconductor substrate to be supported on an upper surface of the substrate support assembly or a plurality of planar heater zones wherein each planar heater zone corresponds to a portion of an upper surface of the substrate support assembly, and wherein the optical fiber includes a plurality of fiber Bragg gratings wherein (i) each fiber Bragg grating is configured to reflect a wavelength of light indicative of a temperature at a different location along the optical fiber, (ii) each fiber Bragg grating is configured to reflect a wavelength of light indicative of the temperature of each of the respective planar heater zones, or (iii) at least two fiber Bragg gratings are configured to each reflect a wavelength of light indicative of a temperature at a different location of each of the respective planar heater zones; or
- (b) the substrate support assembly includes a plurality of planar heater zones wherein each planar heater zone corresponds to a respective device die location of a semiconductor

substrate to be supported on an upper surface of the substrate support assembly or a plurality of planar heater zones wherein each planar heater zone corresponds to a portion of an upper surface of the substrate support assembly, and wherein the optical fiber includes a plurality of long period gratings wherein (i) each long period grating is configured to transmit a wavelength of light indicative of a temperature at a different location along the optical fiber, (ii) each long period grating is configured to transmit a wavelength of light indicative of the temperature of each of the respective planar heater zones, or (iii) at least two long period gratings are configured to each transmit a wavelength of light indicative of a temperature at a different location of each of the respective planar heater zones.

1716. The substrate support assembly of Claim 1615, further comprising a plurality of power supply lines and a plurality of power return lines, wherein each power supply line is connected to at least two planar heater zones, each power return line is connected to at least one planar heater zone, and no two planar heater zones share the same pair of power supply line and power return line.

18. — A method of plasma processing a semiconductor substrate in the apparatus according to Claim 1, comprising:

— supplying the process gas from the process gas source into the plasma processing chamber;

— supplying RF energy into the plasma processing chamber to generate plasma from the process gas; and

— plasma processing a semiconductor substrate in the plasma processing chamber;

— providing light into the laterally extending optical fiber of the component;

— detecting light exiting the laterally extending optical fiber; and

— determining the temperature at different locations along the optical fiber based on the parameters of the light entering and exiting the optical fiber.

19. — The method of Claim 18, wherein:

—— (a) the optical fiber includes a plurality of fiber Bragg gratings along a length thereof, the method further comprising detecting light reflected from each fiber Bragg grating and determining the temperature of the optical fiber at the location of at least two of the fiber Bragg gratings based on the parameters of the light reflected from the respective fiber Bragg gratings;
or

—— (b) the optical fiber includes a plurality of long period gratings along a length thereof, the method further comprising detecting light transmitted through each long period grating and determining the temperature of the optical fiber at the location of at least two of the long period gratings based on the parameters of the light transmitted through the respective long period gratings.

20. — The method of Claim 18, wherein the processing comprises plasma etching the substrate or performing a deposition process.