CLAIMS

~~*What is claimed is:*~~

1. A system comprising:

a process chamber, comprising a chamber wall, a plasma source, and at least two stations, wherein each station comprises a wafer support;

a first camera sensor optically coupled to a first optical access port of a first station of the process chamber;

a second camera sensor is optically coupled to the first optical access port of the process chamber or a second optical access port of the process chamber; and

logic configured to process signals from the first camera sensor and the second camera sensor to characterize one or more properties of a plasma in at least the first station of the process chamber.

2. The system of claim 1, wherein the logic is further configured to account for a feature of at least the second station of the process chamber.

3. The system of claim 1, wherein the process chamber comprises four stations.

4. The system of claim 1, further comprising an optical fiber and/or a light pipe that optically couples the first camera sensor to the first optical access port.

5. The system of claim 4, further comprising a second optical fiber and/or a second light pipe that optically couples the first camera sensor to the second optical access port.

6. The system of claim 4, wherein the first optical access port is an optical lens.

7. The system of claim 4, wherein the first optical access port comprises a window having a maximum cross-sectional dimension of at most about 5 mm.

8. The system of claim 1, wherein the logic is configured to process the signals from the first camera sensor and from the second camera sensor in a multi-threaded process.

9. The system of claim 1, further comprising an edge computer for the process chamber, wherein the logic comprises instructions for executing on the edge computer.

~~10. The system of claim 1, wherein the one or more properties of the plasma comprise a location of the plasma within chamber and/or within at least the first station.~~

~~11.~~10. The system of claim ~~10~~1, wherein the one or more properties of the plasma comprise a location of the plasma within the chamber and/or within at least the first station, and wherein the location comprises at least one of: a centroid of the plasma within the process chamber and/or within the first station; a point or boundary having a defined spectral characteristics of the plasma; or an integrated or summed optical intensity over a bounded region of interest within a field of view of the first camera sensor.

~~12. The system of claim 10, wherein the location comprises a point or boundary having a defined spectral characteristic of the plasma.~~

~~13. The system of claim 10, wherein the location comprises an integrated or summed optical intensity over a bounded region of interest within a field of view of the first camera sensor.~~

~~14.~~11. The system of claim 1, wherein the one or more properties of the plasma comprise at least one of: a pulse characteristic of the plasma; an identification of parasitic plasma; an identification of hollow cathode discharge (HCD); or a location of the plasma within the process chamber and/or within at least the first station.

~~15. The system of claim 1, wherein the one or more properties of the plasma comprise an identification of parasitic plasma.~~

~~16. The system of claim 1, wherein the one or more properties of the plasma comprise an identification of hollow cathode discharge (HCD).~~

~~17.~~12. The system of claim 1, wherein the logic is configured to characterize the one or more properties of the plasma in the first station of the process chamber and wherein the logic is configured to account for a structural feature located in the second station of the process chamber.

~~18.~~13. The system of claim ~~17~~12, wherein the structural feature located in the second station of the process chamber is on a line of sight from the optical access port of the first station that passes through at least a portion of the first station and at least a portion of the second station.

~~19.~~14. The system of claim 1, further comprising a non-camera sensor, and wherein the logic is configured to employ signals from the non-camera sensor to characterize the one or more properties of a plasma in the process chamber.

~~20.~~15. The system of claim 1, wherein the first camera sensor is located and/or oriented to capture first images from a first location or a first angle within the process chamber, and wherein the second camera sensor is located and/or oriented to capture second images from a second location or a second angle within the process chamber.

~~21. The system of claim 20, wherein the logic is further configured to process at least the first images and the second images to produce a spatial representation of the plasma.~~

~~22.~~16. The system of claim 1, wherein the logic is configured to characterize pulses of the plasma.

~~23.~~17. The system of claim 1, further comprising a light source configured to provide lighting in the process chamber while the one or more camera sensors acquire images of the process chamber.

~~24.~~18. The system of claim ~~23~~17, further comprising logic to synchronize the light source and the one or more camera sensors so that the one or more camera sensors acquire the

images of the process chamber while the light source illuminates an interior region of the process chamber.

~~25.~~19. The system of claim 1, wherein the first camera sensor is configured to capture indirect optical information from within the process chamber.

~~26.~~20. The system of claim 1, wherein the logic is further configured to locate an edge of a process chamber component and/or an edge of the plasma from one or more images provided by the first camera sensor.

~~27.~~21. The system of claim 1, wherein the logic is further configured to use the one or more properties of the plasma to diagnose an actual or potential failure or fault with a component of the process chamber.

~~28.~~22. The system of claim 1, wherein the logic is further configured to use the one or more properties of the plasma to characterize a process condition within the process chamber.

~~29.~~23. The system of claim ~~28~~22, wherein the logic is further configured to modify an operation in the process chamber based on the process condition within the process chamber.

~~30.~~24. The system of claim ~~28~~22, wherein the process condition is a process gas composition, a process gas flow characteristic, a pressure within the process chamber, a temperature of one or more components of the process chamber, a plasma power, a plasma frequency, a geometric characteristic of any of the one or more components of the process chamber, or any combination thereof.

~~31.~~25. A method comprising:

obtaining a first image from a first camera sensor, wherein the first image is of at least a portion of a first station of a process chamber, wherein the process chamber comprises a chamber wall, a plasma source, and at least two stations, each comprising a wafer support;

obtaining a second image from a second camera sensor, wherein the second image is of a second region of the process chamber; and

characterizing one or more properties of a plasma in at least the first station of the process chamber, wherein the characterizing is based on the first image and the second image.

~~32.~~26. The method of claim ~~31~~25, wherein characterizing the one or more properties of the plasma in at least the first station comprises identifying one or more contours of elements associated with the first station in the first image and/or the second image.

~~33.~~27. The method of claim ~~32~~26, wherein the one or more elements comprise: a showerhead in the first station, a pedestal in the first station, chamber walls of the first station, or any combination thereof.

~~34.~~28. The method of claim ~~32~~26, wherein the one or more properties comprise identification of hollow cathode discharge (HCD) occurrences, and wherein the method further comprises clustering pixels of the first image and/or the second image into a plurality of categories, at least one category of the plurality of categories corresponding to HCD occurrences.

~~35.~~29. The method of claim ~~31~~25, wherein characterizing the one or more properties of the plasma comprises providing the first image and/or the second image to a trained machine learning model configured to perform segmentation on the first image and/or the second image.

~~36.~~30. The method of claim ~~35~~29, wherein the trained machine learning model is a U-Net architecture.

~~37. A system comprising:~~

~~a process chamber comprising a chamber wall and a plasma source;~~

~~one or more optical access ports in the chamber wall;~~

~~one or more camera sensors optically coupled to the one or more optical access ports in a manner that can capture a two-dimensional image or a three-dimensional image of one or more features of a plasma located within the process chamber; and~~

~~logic configured to process signals from the one or more camera sensors to (i) characterize one or more properties of the plasma at a first region of interest within the process~~

chamber, and (ii) characterize the one or more properties of the plasma at a second region of interest within the process chamber.

38. A method comprising:

receiving image data from the one or more camera sensors, wherein the one or more camera sensors are disposed on or in a process chamber comprising a plasma source, a chamber wall, one or more optical access ports in the chamber wall, wherein the one or more camera sensors are optically coupled to the one or more optical access ports in a manner that can capture a two-dimensional image or a three-dimensional image of one or more features of a plasma located within the process chamber;

characterizing one or more properties of the plasma at a first region of interest within the process chamber; and

characterizing the one or more properties of the plasma at a second region of interest within the process chamber.

39. A system comprising:

a process chamber, comprising a chamber wall and a plasma source;

an optical access port in the chamber wall;

a camera sensor optically coupled to the optical access port;

an auxiliary sensor configured to sense a thermal, optical, and/or electrical condition in the process chamber, wherein the auxiliary sensor is not a camera sensor; and

logic configured to process signals from the camera sensor and the auxiliary sensor to characterize one or more properties of a plasma in the process chamber.

40. A method comprising:

receiving signals from a camera sensor optically coupled to a process chamber, comprising a chamber wall and a plasma source;

receiving signals from an auxiliary sensor that is not a camera sensor; and

characterizing one or more properties of a plasma in the process chamber based at least on part with the signals from camera sensor and the auxiliary sensor.