COMPOSITIONAL OPTICAL EMISSION SPECTROSCOPY FOR DETECTION OF PARTICLE INDUCED ARCS IN A FABRICATION PROCESS

RELATED APPLICATIONS

[0001] This application is based on and claims priority to U.S. Provisional Patent Application No. 62/424,153 entitled "COMPOSITIONAL OPTICAL EMISSION SPECTROSCOPY FOR THE CHARACTERIZATION OF AN ETCH PROCESS" (Ref. No. TEA-138US1-PRO), filed on November 18, 2016.

BACKGROUND

[0002] Plasma fabrication processes including etch processes may be subject to many problems affecting wafer yield, productivity, reliability, and cost. Such problems include arcing in a plasma chamber, where the arcing may be particle induced. It can be very difficult to diagnose such problems. In particular, diagnosis of such problems may involve opening the plasma or process chamber to the atmosphere. Once a chamber is opened to the atmosphere, the chamber is pumped down, purged, seasoned with as many wafers, and the etch process is requalified on production wafers. This cycle can be very costly in terms of tool utilization and fabrication productivity.

SUMMARY OF INVENTION

[0002a] A method for detection of anomalous events in a plasma processing system, comprising:

igniting a plasma in a plasma processing chamber;

detecting a non-spectrally resolved light emission signal and a spectrally-resolved light emission signal from the plasma in the plasma processing chamber, the non-spectrally resolved light emission signal and the spectrally-resolved light emission signal including light emissions from an anomalous event;

detecting a time of the anomalous event from the non-spectrally resolved light emission signal;

selecting a portion of the spectrally-resolved light emission signal in accordance with the time of the anomalous event detected from the non-spectrally resolved light emission signal;

processing the selected portion of the spectrally-resolved light emission signal; and

detecting a signature of the anomalous event from the processed spectrally-resolved light emission signal.

[0002b] An apparatus for detection of anomalous events in a plasma processing system, comprising:

a window disposed on a plasma processing chamber of the plasma processing system, for providing optical access to the plasma processing chamber;

a detector for detecting a non-spectrally resolved light emission signal inside the plasma processing chamber;

a spectrometer for detecting a spectrally-resolved light emission signal inside the plasma processing chamber, through the window; and

a controller configured to

detect a time of the anomalous event from the non-spectrally resolved light emission signal;

select a portion of the spectrally-resolved light emission signal in accordance with the time of the anomalous event detected from the non-spectrally resolved light emission signal; and

process and determine chemical species that caused the anomalous event from the selected portion of the spectrally-resolved light emission signal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] The detailed description is described with reference to accompanying figures. In the figures, the left-most digit(s) of a reference number identifies the figure in which the reference number first appears. The same numbers are used throughout the drawings to reference like features and components.

[0004] FIG. 1 is a cross-sectional view showing an example schematic configuration of a capacitively coupled plasma (CCP) processing system as described in accordance with embodiments herein.

CLAIMS

1. A method for detection of anomalous events in a plasma processing system, comprising:

igniting a plasma in a plasma processing chamber;

detecting a non-spectrally resolved light emission signal and a spectrally-resolved light emission signal from the plasma in the plasma processing chamber, the non-spectrally resolved light emission signal and the spectrally-resolved light emission signal including light emissions from an anomalous event;

detecting a time of the anomalous event from the non-spectrally resolved light emission signal;

selecting a portion of the spectrally-resolved light emission signal in accordance with the time of the anomalous event detected from the non-spectrally resolved light emission signal;

processing the selected portion of the spectrally-resolved light emission signal; and

detecting a signature of the anomalous event from the processed spectrally-resolved light emission signal.

2. The method of claim 1, wherein the anomalous event comprises an arcing event or a plasma instability.

3. The method of claim 1, further comprising:

recording the anomalous event for fault detection or notifying the plasma processing system operator, or both.

4. The method of claim 1, further comprising,

identifying the spectral signature of at least one chemical species from the processed spectrally-resolved light emission signal.

5. The method of claim 4, further comprising:

classifying the anomalous event based on the identified spectral signature of the at least one chemical species.

6. The method of claim 4, further comprising:

determining a source from where the at least one chemical species associated with the identified spectral signature have evolved, into the plasma processing chamber, during the anomalous event.

7. The method of claim 4, further comprising:

identifying a surface from which the at least one chemical species associated with the identified spectral signature have evolved, into the plasma processing chamber, during the anomalous event.

8. The method of claim 4, further comprising:

identifying a location from which the at least one chemical species associated with the identified spectral signature have evolved, into the plasma processing chamber, during the anomalous event.

9. The method of claim 1, further comprising: measuring a plasma electrical parameter; associating the behavior of the plasma electrical parameter during the anomalous event, with the anomalous event.

10. The method of claim 9, wherein the plasma electrical parameter comprises a parameter selected from the group including radio frequency (RF) power, substrate holder RF power, and plasma potential.

11. The method of claim 9, further comprising:

setting the controller to prevent operation of the plasma processing system at conditions identified to be associated with the anomalous event.

12. The method of claim 1, wherein the spectrally-resolved light emission signal is detected using a spectrometer.

13. The method of claim 1, wherein the processing the spectrally-resolved light emission signal is performed in a dedicated arc detector controller.

14. The method of claim 13, wherein the arc detector controller is configured to receive the non-spectrally resolved light emission signal from a high-speed non-spectrally resolved arc detector.

15. The method of claim 14, wherein the arc detector controller is configured to detect an arcing event using both the detected spectrally-resolved light emission signal and the detected non-spectrally resolved light emission signal.

16. The method of claim 1, wherein the processing the spectrally-resolved light emission signal is performed in a plasma endpoint detector controller.

17. An apparatus for detection of anomalous events in a plasma processing system, comprising:

a window disposed on a plasma processing chamber of the plasma processing system, for providing optical access to the plasma processing chamber;

a detector for detecting a non-spectrally resolved light emission signal inside the plasma processing chamber;

a spectrometer for detecting a spectrally-resolved light emission signal inside the plasma processing chamber, through the window; and

a controller configured to

detect a time of the anomalous event from the non-spectrally resolved light emission signal;

select a portion of the spectrally-resolved light emission signal in accordance with the time of the anomalous event detected from the non-spectrally resolved light emission signal; and

process and determine chemical species that caused the anomalous event from the selected portion of the spectrally-resolved light emission signal.

18. The apparatus of claim 17 further comprising a store of spectrally-resolved light emission signals comprising previously pre-identified, stored, and used for reference in an after-the-fact analysis of spectral data to identify the chemical species that caused anomalous events.

19. The apparatus of claim 18, wherein the detector comprises a photodiode detector configured to detect occurrence of arcing events and particular time instant of the occurrence of the arcing events.

20. The apparatus of claim 17, wherein the determination of the chemical species is based upon their corresponding chemical—imprint identifications.