SUMMARY OF INVENTION

[0003] This invention relates to the optimization of a waferless dry clean (WLDC) process in order to reduce the dry etch wafer-to-wafer process variation of patterned device wafers of a lot. Optical Emission Spectroscopy (OES) is used to monitor light emission from a plasma, such as a dry cleaning process that is performed between each process wafer of a lot, to minimize deposition build-up in a plasma processing chamber. The OES of various constituents, such as chlorine (C) and fluorine (F) being exhausted during a dry clean cycle is indicative of the effectiveness of the cleaning process. The OES of the constituents can be used to gauge and optimize the WLDC process in order to improve etch wafer process control.

[0003a] According to an aspect of the present invention, there is provided a method for monitoring and controlling a waferless dry cleaning process performed during processing of a lot of production substrates in a plasma processing system, the method comprising:

processing a first production substrate of the lot in a plasma processing chamber of the plasma processing system;

after removing the first production substrate from the plasma processing chamber, flowing a dry cleaning gas into the plasma processing chamber of the plasma processing system;

igniting a plasma in the plasma processing chamber to initiate a first instance of the waferless dry cleaning process;

acquiring, during the first instance of the waferless dry cleaning process, optical emission spectra from an optical emission spectroscopy system attached to the plasma processing chamber; and

processing a second production substrate of the lot in the plasma processing chamber of the plasma processing system;

after removing the second production substrate from the plasma processing chamber, flowing the dry cleaning gas into the plasma processing chamber of the plasma processing system;

igniting a plasma in the plasma processing chamber to initiate a second instance of the waferless dry cleaning process;

acquiring, during the second instance of the waferless dry cleaning process, optical emission spectra from the optical emission spectroscopy system attached to the plasma processing chamber;

adjusting at least one parameter of the second instance of the waferless dry cleaning process based on the acquired optical emission spectra of the first instance of the waferless dry cleaning process to provide a consistent cleanliness level of the plasma processing chamber during processing of the lot of production substrates.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] 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.

[0005] FIG. 1 is a cross-sectional view showing an example schematic configuration of a capacitively coupled plasma (CCP) processing system in accordance with embodiments herein.

[0006] FIG. 2 is an example schematic block diagram of an example plasma processing system implementing optical emission spectroscopy (OES) to determine OES spectra, as part of an overall monitoring system to monitor gas constituents inside the plasma chamber.

[0007] FIG. 3 are example graphs that illustrate a peak in optical emission spectroscopy (OES) spectra of a residual constituent fluorine (F) by-product during a non-optimized WLDC clean process and the constant increase of the

CLAIMS

What is claimed is:

1. A method for monitoring and controlling a waferless dry cleaning process performed during processing of a lot of production substrates in a plasma processing system, the method comprising:

processing a first production substrate of the lot in a plasma processing chamber of the plasma processing system;

after removing the first production substrate from the plasma processing chamber, flowing a dry cleaning gas into the plasma processing chamber of the plasma processing system;

igniting a plasma in the plasma processing chamber to initiate a first instance of the waferless dry cleaning process;

acquiring, during the first instance of the waferless dry cleaning process, optical emission spectra from an optical emission spectroscopy system attached to the plasma processing chamber; and

processing a second production substrate of the lot in the plasma processing chamber of the plasma processing system;

after removing the second production substrate from the plasma processing chamber, flowing the dry cleaning gas into the plasma processing chamber of the plasma processing system;

igniting a plasma in the plasma processing chamber to initiate a second instance of the waferless dry cleaning process;

acquiring, during the second instance of the waferless dry cleaning process, optical emission spectra from the optical emission spectroscopy system attached to the plasma processing chamber;

adjusting at least one parameter of the second instance of the waferless dry cleaning process based on the acquired optical emission spectra of the first instance of the waferless dry cleaning process to provide a consistent cleanliness level of the plasma processing chamber during processing of the lot of production substrates.

2. The method of claim 1, wherein the plasma processing system is a plasma etching system.

3. The method of claim 1, wherein the plasma processing system is a plasma deposition system.

4. The method of claim 1, wherein the acquiring of optical emission spectra is performed during a waferless dry cleaning process absent production substrates present in the plasma processing chamber.

5. The method of claim 4, wherein the acquiring of optical emission spectra is performed with dummy substrates placed in the plasma processing chamber.

6. The method of claim 1, wherein the at least one parameter of the waferless dry cleaning process is selected from the group consisting of:

radio frequency (RF) or microwave power supplied to the plasma processing chamber;

RF or microwave power pulse frequency;

RF or microwave pulse duty cycle;

RF power supplied to a substrate holder in the plasma processing chamber;

magnetic field of one of more magnets proximate the substrate holder;

direct current (DC) bias of the substrate holder;

DC bias voltage supplied to at least one electrode arranged proximate the substrate holder;

dry cleaning gas flow rate; and

dry cleaning gas pressure.

7. The method of claim 1, wherein the adjusting further comprises adjusting

at least one parameter of the waferless dry cleaning process based on the acquired optical emission spectra to maximize the time between wet cleans of the plasma processing chamber.

8. The method of claim 1, wherein the adjusting further comprises adjusting

at least one parameter of the waferless dry cleaning process based on the acquired optical emission spectra to maximize the lifetime of a component of the plasma processing chamber.

9. The method of claim 1, wherein the adjusting further comprises adjusting

at least one parameter of the waferless dry cleaning process based on the acquired optical emission spectra to minimize particle generation in the plasma processing chamber.

10. The method of claim 1, wherein the adjusting further comprises adjusting

at least one parameter of the waferless dry cleaning process based on the acquired optical emission spectra to maximize critical dimension (CD) uniformity of a subsequently processed production substrate or lot of production substrates.

11. The method of claim 1, wherein the optimizing of the at least one parameter of the waferless dry cleaning process is performed using optical emission spectra acquired with dummy substrates placed in the plasma processing chamber.

12. The method of claim 1, wherein the optimizing of the at least one parameter of the waferless dry cleaning process is performed ex-situ.

13. The method of claim 1, wherein the optimizing of the at least one parameter of the waferless dry cleaning process is performed in-situ.

14. The method of claim 1, wherein the dry cleaning gas comprises oxygen, an oxygen-containing gas, HCl, F2, Cl2, hydrogen, nitrogen, argon, SF6, C2F6, NF3, CF4, or a mixture of two or more thereof.

15. The method of claim 1, further comprising:

terminating the waferless dry cleaning process when the acquired optical emission spectra substantially match a predetermined target optical emission spectrum,

wherein the target optical emission spectrum is characteristic for a plasma processing chamber for a predetermined acceptable clean condition.

16. The method of claim 1, further comprising:

terminating the waferless dry cleaning process when content of a residual constituent approaches a determined level based on OES endpoint analysis.