

CLAIMS

What is claimed is:

1. A method for monitoring and controlling a waferless dry cleaning process in a plasma processing system, the method comprising:
 flowing a dry cleaning gas into a plasma processing chamber of the plasma processing system;
 igniting a plasma in the plasma processing chamber to initiate the waferless dry cleaning process; and
 acquiring optical emission spectra from an optical emission spectroscopy system attached to the plasma processing chamber, during the waferless dry cleaning process.
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, further comprising:
optimizing at least one parameter of the waferless dry cleaning process
based on the acquired optical emission spectra.

7. The method of claim 6, 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;

dry cleaning gas pressure; and

duration of the waferless dry cleaning process.

8. The method of claim 6, wherein the optimization of the at least
one parameter of the waferless dry cleaning process is performed to maximize
the time between wet cleans of the plasma processing chamber.

9. The method of claim 6, wherein the optimizing of the at least one
parameter of the waferless dry cleaning process is performed to minimize the
duration of the waferless dry cleaning process.

10. The method of claim 6, wherein the optimizing of the at least one parameter of the waferless dry cleaning process is performed to maximize the lifetime of a component of the plasma processing chamber.

11. The method of claim 6, wherein the optimizing of the at least one parameter of the waferless dry cleaning process is performed to minimize particle generation in the plasma processing chamber.

12. The method of claim 6, wherein the optimizing of the at least one parameter of the waferless dry cleaning process is performed to maximize critical dimension (CD) uniformity of a subsequently processed production substrate or lot of production substrates.

13. The method of claim 6, 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.

14. The method of claim 6, wherein the optimizing of the at least one parameter of the waferless dry cleaning process is performed ex-situ.

15. The method of claim 6, wherein the optimizing of the at least one parameter of the waferless dry cleaning process is performed in-situ.

16. The method of claim 6, wherein the optimizing of the at least one parameter of the waferless dry cleaning process is performed to minimize the duration of the waferless dry cleaning process.

17. 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.

18. 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.

19. 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.

20. A non-transitory machine-accessible storage medium having instructions stored thereon which cause a data processing system to perform a method for monitoring and controlling a waferless dry cleaning process in a plasma processing tool, the method comprising:

flowing a dry cleaning gas into a plasma processing chamber of the plasma processing system;

igniting a plasma in the plasma processing chamber to initiate the waferless dry cleaning process; and

acquiring optical emission spectra from an optical emission spectroscopy system attached to the plasma processing chamber, during the waferless dry cleaning process.

21. The storage medium of claim 20, wherein the method for monitoring and controlling a waferless dry cleaning process in a plasma processing tool further comprises:

optimizing at least one parameter of the waferless dry cleaning process based on the acquired optical emission spectra.

22. The storage medium of claim 20, wherein the method for monitoring and controlling a waferless dry cleaning process in a plasma processing tool further comprises:

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 in a clean condition.

23. A plasma processing system comprising:

one or more controllers;

a plasma processing chamber;

a process gas supply system controlled by the one or more controllers, that flows into the plasma processing chamber, wherein the one or more controllers initiate an ignition of a plasma in the plasma processing chamber to initiate the waferless dry cleaning process; and

an optical spectroscopy system attached to the plasma processing chamber that acquires optical emission spectra during the waferless dry cleaning process.

24. An in situ method of monitoring and controlling a waferless dry cleaning (WLDC) process in a plasma processing tool, the method comprising:

- initiating a production process of a wafer lot;
- collecting in-situ monitoring data during the production process;
- performing in-situ data analysis of the wafer lot; and
- adjusting parameters of the WLDC process based on the in-situ monitoring data.

25. The method of claim 24, wherein the in-situ monitoring data is collected by performing a method comprising:

- flowing a dry cleaning gas into a plasma processing chamber of the plasma processing system;

- igniting a plasma in the plasma processing chamber to initiate the waferless dry cleaning process; and

- monitoring the plasma in the plasma processing chamber during the waferless dry cleaning process using a monitoring system,

- wherein the monitoring system comprises an optical emission spectroscopy system, a laser induced fluorescence system, a laser interferometer, a residual gas analyzer, a mass spectrometer, or a Fourier Transform Infrared (FTIR) system.

26. The method of claim 24, wherein the plasma processing tool is a plasma etching system.

27. The method of claim 24, wherein the plasma processing tool is a plasma deposition system.

28. The method of claim 24, wherein the monitoring the plasma acquires optical emission spectra is performed during the waferless dry cleaning process absent production substrates present in the plasma processing chamber.

29. The method of claim 28, wherein the acquiring of optical emission spectra is performed with dummy substrates placed in the plasma processing chamber.

30. The method of claim 28, further comprising:
optimizing at least one parameter of the waferless dry cleaning process based on the acquired optical emission spectra.

31. The method of claim 30, 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;

dry cleaning gas pressure; and

duration of the waferless dry cleaning process.

32. The method of claim 30, wherein the optimization of the at least one parameter of the waferless dry cleaning process is performed to maximize the time between wet cleans of the plasma processing chamber.

33. The method of claim 30, wherein the optimizing of the at least one parameter of the waferless dry cleaning process is performed to minimize the duration of the waferless dry cleaning process.

34. The method of claim 30, wherein the optimizing of the at least one parameter of the waferless dry cleaning process is performed to maximize the lifetime of a component of the plasma processing chamber.

35. The method of claim 30, wherein the optimizing of the at least one parameter of the waferless dry cleaning process is performed to minimize particle generation in the plasma processing chamber.

36. The method of claim 30, wherein the optimizing of the at least one parameter of the waferless dry cleaning process is performed to maximize critical dimension (CD) uniformity of a subsequently processed production substrate or lot of production substrates.

37. The method of claim 30, 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.

38. The method of claim 30, wherein the optimizing of the at least one parameter of the waferless dry cleaning process is performed ex-situ.

39. The method of claim 30, wherein the optimizing of the at least one parameter of the waferless dry cleaning process is performed in-situ.

40. The method of claim 30, wherein the optimizing of the at least one parameter of the waferless dry cleaning process is performed to minimize the duration of the waferless dry cleaning process.

41. A non-transitory machine-accessible storage medium having instructions stored thereon which cause a data processing system to perform a method for monitoring and controlling a waferless dry cleaning process in a plasma processing tool, the method comprising:

- starting a production process of a wafer lot;
- gathering in-situ monitoring data during the production process;
- analyzing in-situ data of the wafer lot; and
- recalculating parameters of the WLDC process based on the in-situ monitoring data.

42. The storage medium of claim 41, wherein the method for monitoring and controlling a waferless dry cleaning process in a plasma processing tool further comprises:

- optimizing at least one parameter of the waferless dry cleaning process based on the acquired optical emission spectra.

43. The storage medium of claim 41, wherein the method for monitoring and controlling a waferless dry cleaning process in a plasma processing tool further comprises:

- 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 in a clean condition.