

aspects of the description which may not otherwise qualify as prior art at the time of filing, are neither expressly or impliedly admitted as prior art against the present invention.

SUMMARY

[0007] An aspect of the present disclosure includes an apparatus for in-situ etching monitoring in a plasma processing chamber. The apparatus includes a continuous wave broadband light source; an illumination system configured to illuminate an area on a substrate with an incident light beam having a fixed polarization direction, the incident light beam from the broadband light source being modulated by a shutter; a collection system configured to collect a reflected light beam being reflected from the illuminated area on the substrate, and direct the reflected light beam to a detector; and processing circuitry. The processing circuitry is configured to process the reflected light beam to suppress background light, determine a property value from the processed light using a training model, and control an etch process based on the determined property value.

[0008] Another aspect of the present disclosure includes a plasma processing system. The system includes a plasma processing chamber and an oblique incidence reflectometer. The oblique incidence

reflectometer includes a continuous wave broadband light source, a detector, an illumination system configured to illuminate an area on a substrate deposited in the plasma processing chamber with an incident light beam having a fixed polarization direction, the incident light beam from the broadband light source being modulated by a shutter, a collection system configured to collect a reflected light beam being reflected from the illuminated area on the substrate, and direct the reflected light beam to the detector, and processing circuitry. The processing circuitry is configured to process the reflected light beam to suppress background light, determine a property value from the processed light using a training model, and control an etch process based from the determined property value.

[0009] Another aspect of the present disclosure includes a method for in-situ etching monitoring. The method includes acquiring a background corrected spectrum associated with a reflected light beam during an etch process, the reflected light beam being formed from the reflection of a modulated incident light beam having a fixed polarization direction from an area of a substrate deposited in a plasma processing chamber, the incident light beam being from a broadband light source being modulated using a shutter; determining a property value associated with the background corrected spectrum using a training model; and controlling the etch process based on the determined property value.

CLAIMS

1. An apparatus for in-situ etching monitoring in a plasma processing chamber, the apparatus comprising:
 - a continuous wave broadband light source;
 - an illumination system configured to illuminate an area on a substrate with an incident light beam having a fixed polarization direction, the incident light beam from the broadband light source being modulated by a shutter;
 - a collection system configured to
 - collect a reflected light beam being reflected from the illuminated area on the substrate, and
 - direct the reflected light beam to a detector; and
 - processing circuitry configured to
 - process the reflected light beam to suppress background light,
 - determine a property value from the processed light using a training model, and
 - control an etch process based on the determined property value.

2. The apparatus of claim 1, wherein the broadband light source is a laser driven plasma light source.
3. The apparatus of claim 1, wherein the illumination system includes a Rochon polarizer; and
the collection system includes a second Rochon polarizer configured to allow p-polarized light reflected from the substrate to reach the detector.
4. The apparatus of claim 1, wherein the illumination system and the collection system include reflective relay optics.
5. The apparatus of claim 4, wherein the reflective relay optics include off-axis parabolic mirrors.
6. The apparatus of claim 4, wherein the reflective relay optics include concave mirrors and convex mirrors.
7. The apparatus of claim 1, wherein the incident light beam has an angle of incidence between 0 to 90 degrees with respect to a normal of the substrate.

8. The apparatus of claim 7, wherein the angle of incidence is between 45 degrees to 90 degrees.
9. The apparatus of claim 8, wherein the angle of incidence is 85 degrees or 64 degrees.
10. The apparatus of claim 1, further comprising a step motor configured to move the shutter between two positions, wherein in a first position the shutter is configured to block the incident light beam from reaching the plasma processing chamber and in a second position the shutter is configured to allow the incident light beam into the plasma processing chamber.
11. The apparatus of claim 1, wherein the shutter is a chopper wheel.
12. The apparatus of claim 1, further comprising:
a second illumination system configured to illuminate the area of the substrate with a second incident light beam having a second angle of incidence, the second angle of incidence being different from the angle of incidence of the incident light beam from the illumination system, the second incident light beam being reflected from the substrate to form a second reflected light beam;

a second collection system configured to
collect the second reflected light beam, and
direct the second reflected light beam to the detector.

13. The apparatus of claim 1, further comprising:

a first optical window configured to transmit the incident light
beam;

a second optical window configured to transmit the reflected light
beam; and

wherein the first optical window and the second optical window are
mounted on the wall of the plasma processing chamber opposite of
each other.

14. The apparatus of claim 1, further comprising:

a first optical window configured to transmit the incident light
beam;

a second optical window configured to transmit the reflected light
beam; and

wherein the first optical window and the second optical window are
mounted on a top wall of the plasma processing chamber.

15. The apparatus of claim 1, further comprising:

a reference system configured to direct a percentage of the incident light beam to a reference channel of the detector.

16. The apparatus of claim 1, wherein the detector is an ultra-broadband spectrometer.

17. A plasma processing system, the system comprising:

a plasma processing chamber; and

an oblique incidence reflectometer including

a continuous wave broadband light source,

a detector,

an illumination system configured to illuminate an area

on a substrate deposited in the plasma processing chamber with

an incident light beam having a fixed polarization direction, the

incident light beam from the broadband light source being

modulated by a shutter,

a collection system configured to

collect a reflected light beam being reflected from

the illuminated area on the substrate, and

direct the reflected light beam to the detector,

and

processing circuitry configured to

process the reflected light beam to suppress
background light,
determine a property value from the processed
light using a training model, and
control an etch process based from the
determined property value.

18. The system of claim 17, wherein the broadband light source is a
laser driven plasma light source.

19. A method for in-situ etching monitoring, the method comprising:
acquiring a background corrected spectrum associated with
a reflected light beam during an etch process, the reflected light beam
being formed from the reflection of a modulated incident light beam
having a fixed polarization direction from an area of a substrate
deposited in a plasma processing chamber, the incident light beam
being from a broadband light source being modulated using a shutter;
determining a property value associated with the background
corrected spectrum using a training model; and
controlling the etch process based on the determined
property value.

20. The method of claim 19, wherein the training model is a regression model when the substrate is un-patterned and a machine learning algorithm when the substrate is patterned.