

may be represented by a continuous signal curve - as a detected or derived optical emission spectroscopy (OES) data - from the plasma etch processing system. In this example, the continuous signal curve (i.e., detected OES data) may include transient signals (e.g., spikes or noise in between process-steps) and accordingly, the
5 continuous signal curve may further be synchronized, filtered, and averaged prior to performing of the endpoint detection as described herein.

[0010a] According to a first aspect of the present invention, there is provided a method for determining process endpoint data in a plasma processing system, comprising:

receiving optical emission spectroscopy (OES) data from a plasma processing chamber of the plasma processing system that performs a multi-step plasma process of a substrate that is an atomic layer etch (ALE) process, wherein the multi-step plasma process is cyclical and comprises at least two process steps that are cyclically repeated, and the at least two process steps comprise an absorption step and a desorption step;

determining a first quiescent portion of the received OES data, the first quiescent portion is an average of the absorption step of the ALE process;

determining a second quiescent portion of the received OES data, the second quiescent portion is an average of a desorption step of the ALE process; and

determining a first endpoint of the determined first quiescent portion.

[0010b] According to a second aspect of the present invention, there is provided a method for determining process endpoint data in a plasma processing system, comprising:

receiving optical emission spectroscopy (OES) data from a plasma processing chamber of the plasma processing system that performs a multi-step plasma process of a substrate, wherein the multi-step plasma process is cyclical and

comprises at least two process steps that are cyclically repeated;

determining a first quiescent portion of the received OES data, the first quiescent portion is an average of a filtered process-step of the multi-step plasma process; and

determining a first endpoint of the determined first quiescent portion,

wherein determining the first endpoint comprises:

providing a previously-calculated and stored mean optical emission spectroscopy (OES) data matrix $[S_{avg}]$;

providing a previously-calculated and stored principal component weights vector $[P]$;

forming optical emission spectroscopy (OES) data sets from a first quiescent signal at predetermined time intervals during the cyclical multi-step plasma process;

from each optical emission spectroscopy (OES) data set, subtracting the previously provided mean optical emission spectroscopy (OES) data matrix $[S_{avg}]$, to de-mean each optical emission spectroscopy (OES) data set;

transforming each de-meant and non-normalized optical emission spectroscopy (OES) data set into transformed optical emission spectroscopy (OES) data, by calculating at least one element of the transformed optical emission spectroscopy (OES) data vector $[T]$ using the provided principal component weights vector $[P]$;

from the calculated at least one element of the transformed optical emission spectroscopy (OES) data vector $[T]$, further calculating a trend variable $f(T_i)$; and

detecting the first endpoint of the cyclical multi-step plasma process from the calculated values of the trend variable $f(T_i)$ during the cyclical multi-step plasma process.

[0011] In an implementation, the synchronized, filtered, and averaged continuous signal curve may further be delineated and/or identified to provide: a first quiescent portion, which may represent for example, an average of an absorption - step process of the multi-process step; and/or a second quiescent portion, which may represent, 5 for example, an average of a desorption - step process of the multi-process step. In this implementation, the endpoint detection process may be based from the first quiescent portion alone, the second quiescent portion alone, or an average of the first and second quiescent portions. In other implementations, where the transients/noises are negligible in values, the endpoint detection may utilize directly 10 the detected continuous signal curve. That is, the detected synchronized continuous signal curve or OES data with negligible transient signals.

[0012] As described herein, the first quiescent portion may represent an average of a filtered upper envelope (i.e., absorption – step process) of the continuous signal curve or OES data. On the other hand, the second quiescent portion may represent 15 an average of a filtered lower envelope (i.e., desorption – step process) of the continuous signal curve or OES data.

[0013] The filtered upper envelope and filtered lower envelope denote removal of transient signals that may be present at the upper and lower envelope, respectively, of the OES data.

20 **[0014]** In an embodiment, the OES data are detected and acquired by a sensor from an etching process block and particularly, from a plasma processing chamber of the plasma etch processing system. The detection and acquisition by the sensor is synchronized, for example, with regard to initiation of the step - process (e.g.,

CLAIMS

1. A method for determining process endpoint data in a plasma processing system, comprising:

receiving optical emission spectroscopy (OES) data from a plasma processing chamber of the plasma processing system that performs a multi-step plasma process of a substrate that is an atomic layer etch (ALE) process, wherein the multi-step plasma process is cyclical and comprises at least two process steps that are cyclically repeated, and the at least two process steps comprise an absorption step and a desorption step;

determining a first quiescent portion of the received OES data, the first quiescent portion is an average of the absorption step of the ALE process;

determining a second quiescent portion of the received OES data, the second quiescent portion is an average of a desorption step of the ALE process;
and

determining a first endpoint of the determined first quiescent portion.

2. The method of claim 1, wherein the at least two process steps includes a transient signal--filtered absorption step or a transient signal--filtered desorption step.

3. The method of claim 1, wherein the receiving of optical emission spectroscopy (OES) data is synchronized with the at least two process steps that are cyclically repeated.

4. The method of claim 1, further comprising: removing transients associated with

switching the at least two process steps prior to the determining of the first quiescent portion.

5. The method of claim 1, wherein the first quiescent portion is derived from an upper envelope of the OES data acquired.

6. The method of claim 1, further comprising:

determining an average of the first quiescent portion and the second quiescent portion.

7. The method of claim 6, wherein the determining of the first endpoint is based from the determined second quiescent portion.

8. The method of claim 6, wherein the determining of the first endpoint is based from the average of the first quiescent portion and the second quiescent portion.

9. The method of claim 1, wherein the determining the first quiescent portion comprises an application of a moving average filter to the at least two process steps.

10. The method of claim 1, further comprising:

removing transient signals of the received OES data prior to the determining of the first endpoint based on a second quiescent signal.

11. The method of claim 10, wherein determining a second endpoint based on the second quiescent data comprises a principal component analysis.

12. The method of claim 1, wherein determining of the first endpoint comprises a principal component analysis.

13. A method for determining process endpoint data in a plasma processing system, comprising:

receiving optical emission spectroscopy (OES) data from a plasma processing chamber of the plasma processing system that performs a multi-step plasma process of a substrate, wherein the multi-step plasma process is cyclical and comprises at least two process steps that are cyclically repeated;

determining a first quiescent portion of the received OES data, the first quiescent portion is an average of a filtered process-step of the multi-step plasma process; and

determining a first endpoint of the determined first quiescent portion,

wherein determining the first endpoint comprises:

providing a previously-calculated and stored mean optical emission spectroscopy (OES) data matrix $[S_{avg}]$;

providing a previously-calculated and stored principal component weights vector $[P]$;

forming optical emission spectroscopy (OES) data sets from a first quiescent signal at predetermined time intervals during the cyclical multi-step plasma process;

from each optical emission spectroscopy (OES) data set, subtracting the previously provided mean optical emission spectroscopy (OES) data matrix $[S_{avg}]$, to de-mean each optical emission spectroscopy (OES) data set;

transforming each de-meaned and non-normalized optical emission spectroscopy (OES) data set into transformed optical emission spectroscopy (OES) data, by calculating at least one element of the transformed optical

emission spectroscopy (OES) data vector $[T]$ using the provided principal component weights vector $[P]$;

from the calculated at least one element of the transformed optical emission spectroscopy (OES) data vector $[T]$, further calculating a trend variable $f(T_i)$; and

detecting the first endpoint of the cyclical multi-step plasma process from the calculated values of the trend variable $f(T_i)$ during the cyclical multi-step plasma process.