methods such as endpoint detection (EPD), in which precise timing of the process endpoint is of paramount importance.

[0008] With present demands of process diagnostics, particularly etch diagnostics, the aforementioned tradeoffs are becoming more severe with every new generation of devices and processes. Therefore, the need exists for a new spectrometer design and optical diagnostic system to be used in in-situ semiconductor processing diagnostics and control, which does not require sacrificing throughput and spectral resolution for increasing signal to noise ratio (SNR), or which minimizes these tradeoffs.

[0009] To that end, this invention proposes a system and method for optical diagnostics and control of a semiconductor manufacturing process using hyperspectral imaging technology as replacement for a conventional spectrometer.

[0010] Because hyperspectral imaging is an imaging technique, it is applicable to an even wider range of optical diagnostic methods in semiconductor processing. For example, optical diagnostics that involve imaging of the substrate or region(s) of the substrate to determine the state of the substrate and structures and layers formed thereupon, where the diagnostics would benefit from the knowledge of full spectral information afforded by hyperspectral imaging, are all good candidates for the use of this technology. Examples of optical diagnostics where hyperspectral imaging can be employed include various optical imaging inspection steps, such as after-develop inspection (ADI) in photolithographic patterning processes, various imaging defect inspection steps, detection of contamination on the substrate, etc.

SUMMARY OF THE INVENTION

[0011] The present invention relates to methods, and multiple embodiments of an apparatus and system for hyperspectral imaging, to diagnose the state of a substrate during semiconductor processing, and/or to optically diagnose and control the state of a semiconductor manufacturing process itself.

[0011a] According to a first aspect of the present invention, there is provided an optical detector for detecting an optical signal from a semiconductor processing system, the optical detector being configured for detecting an optical signal transmitted through a window mounted in a wall of the semiconductor processing system, the optical detector comprising:

collecting optics, configured for collecting and transmitting the optical signal transmitted by the window;

a wavelength tunable filter for tunably selecting a wavelength of the transmitted optical signal;

an array detector for detecting the wavelength-filtered optical signal; and

a controller for controlling at least the wavelength tunable filter and array detector, and for storing and processing images acquired by the array detector.

[0011b] According to a second aspect of the present invention, there is provided an optical detector for detecting an optical signal reflected from a substrate in a semiconductor substrate inspection system, the optical detector comprising:

collecting optics, configured for collecting and transmitting the optical signal;

a wavelength tunable filter for tunably selecting a wavelength of the transmitted optical signal;

an array detector for detecting the wavelength-filtered optical signal; and

a controller for controlling at least the wavelength tunable filter and array detector, and for storing and processing images acquired by the array detector.

[0011c] According to a third aspect of the present invention, there is provided a semiconductor processing system, comprising:

a window mounted in a wall of the semiconductor processing system;

collecting optics, configured for collecting and transmitting an optical signal transmitted by the window from the semiconductor processing system;

a wavelength tunable filter for tunably selecting a wavelength of the transmitted optical signal;

an array detector for detecting the wavelength-filtered optical signal; and

a controller for controlling at least the wavelength tunable filter and array detector, and for storing and processing images acquired by the array detector.

[0011d] According to a fourth aspect of the present invention, there is provided a method for diagnosing a plasma process step in a plasma processing system, comprising:

igniting a plasma in a plasma processing chamber of the plasma processing system;

collecting a plasma optical emission signal through a window mounted in a wall of the plasma processing chamber, and through collecting optics;

directing the plasma optical emission signal from the collecting optics into a wavelength tunable filter for tunably selecting a wavelength of the collected plasma optical emission signal;

detecting the wavelength-filtered plasma optical emission signal using an array detector; and

storing and processing images acquired by the array detector in a controller,

wherein the controller is configured for controlling at least the wavelength tunable filter and the array detector.

[0011e] According to a fifth aspect of the present invention, there is provided a method for measuring at least one property of at least one layer or structure formed on a substrate disposed in a semiconductor processing system, comprising:

initiating a process step in the semiconductor processing system;

illuminating the substrate with an illumination beam, the portion of the illumination beam reflected and diffracted from the substrate forming a diffracted optical signal;

collecting the diffracted optical signal through a window mounted in a wall of the semiconductor processing system, and through collecting optics;

tunably selecting a wavelength of either the illumination beam or the diffracted optical signal using a wavelength tunable filter disposed in either the illumination beam or the diffracted optical signal, respectively, to form a wavelength-filtered diffracted optical signal;

detecting the wavelength-filtered diffracted optical signal using an array detector; and

storing and processing images acquired by the array detector in a controller,

wherein the controller is configured for controlling at least the wavelength tunable filter and the array detector.

[0011f] According to a sixth aspect of the present invention, there is provided a method for inspecting a substrate in a substrate inspection system, comprising:

placing the substrate on a stage in the substrate inspection system;

illuminating the substrate with an illumination light source;

collecting an optical signal caused by illuminating the substrate, through collecting optics;

directing the collected optical signal from the collecting optics into a wavelength tunable filter for tunably selecting a wavelength of the collected optical signal;

detecting the wavelength-filtered signal using an array detector; and

storing and processing images acquired by the array detector in a controller,

wherein the controller is configured for controlling at least the wavelength tunable filter and the array detector.

[0012] In one embodiment, an optical detector for detecting an optical signal from a semiconductor processing system is provided. The optical detector is configured for detecting an optical signal transmitted through a window mounted in a wall of the semiconductor processing system. The optical detector comprises collecting optics, configured for collecting and transmitting the optical signal transmitted by the window; a wavelength tunable filter for tunably selecting a wavelength of the transmitted optical