described in this background section, as well as 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 OF THE INVENTION

[0004a] According to a first aspect of the present invention, there is provided a method for inspecting a substrate, comprising:

illuminating the substrate with a laser beam having a spatial phase singularity forming an illuminated spot on the substrate and a standing wave, the standing wave having at least one bright fringe and at least one dark fringe on the substrate, the at least one bright fringe extending over at least a portion of the illuminated spot; and

detecting, by a dark field optical detection system, scattered light from nano-defects present on the substrate within the illuminated spot.

[0004b] According to a second aspect of the present invention, there is provided a system for inspection a substrate, comprising:

a substrate stage for receiving the substrate;

a laser light source;

illumination optics for directing light from the laser light source on the substrate, wherein the illumination optics are configured to form a laser beam having a spatial phase singularity for forming an illuminated spot on the substrate and a standing wave having at least one bright fringe and at least one dark fringe on the substrate; and

a dark field optical detection system for detecting illuminated nano-defects by detecting scattered light from the illuminated nano-defects on the substrate.

[0004c] According to a third aspect of the present invention, there is provided an apparatus for inspecting a substrate, comprising:

an illumination system for forming a laser beam having a spatial phase singularity from a laser light source and directing the laser beam to the substrate, the laser beam forming an illuminated spot and a standing wave having at least one bright fringe and at least one dark fringe on the substrate; and

a dark field optical detection system for detecting illuminated nano-defects by detecting scattered light from the illuminated nano-defects on the substrate.

[0005] There is provided a method for inspecting a substrate comprising illuminating the substrate with a singular laser beam, the singular laser beam forming an illuminated spot on the substrate and a bright fringe at a surface of the substrate, the bright fringe extending over at least a portion of the illuminated spot; and detecting, by an optical detection system, scattered light from nano-defects present on the substrate within the illuminated spot.

[0006] There is provided a system for inspecting a substrate. The system includes a substrate stage for receiving the substrate, a laser light source, illumination optics for directing light from the laser light source to a surface of the substrate, wherein the illumination optics are configured to form a singular laser beam for illuminating the substrate, and an optical detection system for detecting illuminated nano-defects by detecting scattered light from the illuminated nano-defects on the substrate.

[0007] There is provided an apparatus for inspecting a substrate. The apparatus includes an illumination system for forming a singular laser beam from a laser light source and directing the singular laser beam to the substrate,

What is claimed is:

1. A method for inspecting a substrate, comprising:

illuminating the substrate with a laser beam having a spatial phase singularity forming an illuminated spot on the substrate and a standing wave, the standing wave having at least one bright fringe and at least one dark fringe on the substrate, the at least one bright fringe extending over at least a portion of the illuminated spot; and

detecting, by a dark field optical detection system, scattered light from nano-defects present on the substrate within the illuminated spot.

2. The method of claim 1, wherein the laser beam has at least two beam portions separated by a phase difference.

3. The method of claim 2, wherein the phase difference is π radians.

4. The method of claim 2, wherein the phase difference of the laser beam is formed using a phase mask or a phase retarder.

5. The method of claim 1, wherein the laser beam has an s polarization orientation at the substrate or a p polarization orientation at the substrate.

6. The method of claim 1, wherein an angle of incidence of the singular laser beam at the substrate is from about 1° to about 90°.

7. The method of claim 1, wherein the laser beam includes a light wavelength in the extreme ultraviolet (EUV), deep ultraviolet (DUV), ultraviolet (UV), or visible portions of the light spectrum, or a combination of two or more thereof.

8. The method of claim 1, wherein the dark field optical detection system is configured to detect scattered light from the nano-defects in a direction substantially perpendicular to the substrate.

9. The method of claim 1, wherein the dark field optical detection system comprises:

an objective lens;

a configurable imaging aperture;

relay optics;

a bandpass filter; and

a detector array.

10. The method of claim 9, wherein the detector array comprises a photomultiplier tube (PMT) array or a time delay integration charge-coupled device (TDI CCD) array.

11. The method of claim 9, wherein the objective lens is optimized to minimize chromatic aberrations.

12. The method of claim 9, wherein the dark field optical detection system further comprises:

an autofocus system for maintaining focus during detection of scattered light from nano-defects on the substrate.

13. The method of claim 9, wherein the dark field optical detection system further comprises:

an image computer for signal processing an acquired optical signal from scattered light from illuminated nano-defects and for determining if a nano-defect occurs within the field of view of the dark field optical detection system.

14. The method of claim 1, wherein the nano-defects include defects located atop the substrate and all layers formed on the substrate.

15. A system for inspection a substrate, comprising:

a substrate stage for receiving the substrate;

a laser light source;

illumination optics for directing light from the laser light source on the substrate, wherein the illumination optics are configured to form a laser beam having a spatial phase singularity for forming an illuminated spot on the substrate and a standing wave having at least one bright fringe and at least one dark fringe on the substrate; and

a dark field optical detection system for detecting illuminated nano-defects by detecting scattered light from the illuminated nano-defects on the substrate.

16. The system of claim 15, further comprising:

a purge chamber, wherein the substrate stage is deposited in the purge chamber.

17. The system of claim 15, wherein the dark field optical detection system comprises:

an objective lens;

a configurable imaging aperture;

relay optics;

a bandpass filter and

a detector array.

18. The system of claim 17, wherein the detector array includes a photomultiplier tube (PMT) array or a time delay integration charge-coupled device (TDI CCD) array.

19. The system of claim 17, wherein the dark field optical detection system further comprises:

an autofocus system for maintaining focus during detection of scattered light from nano-defects on the substrate.

20. An apparatus for inspecting a substrate, comprising:

an illumination system for forming a laser beam having a spatial phase singularity from a laser light source and directing the laser beam to the substrate, the laser beam forming an illuminated spot and a standing wave having at least one bright fringe and at least one dark fringe on the substrate; and

a dark field optical detection system for detecting illuminated nano-defects by detecting scattered light from the illuminated nano-defects on the substrate.