CLAIMS

What is claimed is:

1. A method for inspecting phase defects and/or particles on a surface of an unpatterned object, the method comprising:

generating an illuminating light beam having a wavelength of less than about 250 nanometers;

passing the illuminating light beam through a set of optical elements with a partial coherence sigma to between about 0.15 and 0.5;

focusing the illuminating light beam onto the surface of the unpatterned object at a predetermined defocus range;

inspecting the surface of the unpatterned object with the illuminating light beam so that a reflected light beam reflects from the surface; and

based on the reflected light beam, constructing and analyzing a resultant image to identify the phase defects.

2. The method of claim 1, wherein the phase defects are less than about 10 nanometers in height and less than about 200 nanometers in a full width at half maximum (FWHM).

3. The method of claim 1, wherein the phase defects are less than about 2 nanometers in height and less than about 100 nanometers in FWHM.

4. The method of claim 1, wherein the predetermined defocus range is between about +1 and +3 depth of field (DOF) or between about -1 and -3 DOF.

5. The method of claim 1, further comprising focusing a second illuminating light beam onto the surface of the unpatterned object at a second predetermined defocus range, wherein the predetermined defocus range is between about +1 and +3 depth of field (DOF) and the second predetermined defocus range is between about -1 and -3 DOF.

6. The method of claim 1, wherein constructing and analyzing the resultant image comprises capturing the reflected light beam with a time delay integration (TDI) detector.

7. The method of claim 6, wherein a path of the reflected light beam is between about 100 pixels and 1000 pixels wide along a scanning direction defined by a resolution of the TDI detector.

8. The method of claim 1, wherein the illuminating light beam is a deep UV beam or an extreme UV beam.

9. The method of claim 1, wherein the illuminating light beam has a wavelength of about 193 nanometers.

10. The method of claim 1, wherein the partial coherence sigma is adjusted to between about 0.2 and 0.4.

11. The method of claim 1, wherein analyzing the resultant image comprises constructing and applying a filter to the resultant image or a detected signal generated from the reflected light beam so as to maximize a signal-to-noise (SNR) ratio in the resultant image or detected signal.

12. The method of claim 1, further comprising applying a correction factor to remove a systematic noise comprising TDI calibration effects from the resultant image.

13. The method of claim 12, wherein the correction factor is determined and applied during inspecting from initial capturing of the reflected light beam.

14. The method of claim 12, wherein the correction factor is determined from intensity variations of a reflected light.

15. The method of claim 1, wherein analyzing the resultant image comprises applying a threshold signal value of at least about 7 to detect phase defects.

16. The method of claim 1, wherein the unpatterned object comprises an Extreme Ultraviolet Mask (EUV) blank.

17. The method of claim 1, wherein the unpatterned object is a transmissive object.

18. The method of claim 1, wherein the surface of the unpatterned object comprises quartz or an anti-reflective coating (ARC).

19. The method of claim 1, wherein constructing and analyzing the resultant image comprises capturing reflected light with a dual-field TDI detector configured to construct two initial images of the surface of an unpatterned object.

20. The method of claim 19, wherein the two initial images are constructed for two different defocus values.

21. The method of claim 20, wherein the two different defocus values are opposite in sign.

22. The method of claim 20, wherein the two initial images comprise a focused image constructed for a DOF of about zero.

23. The method of claim 22, wherein the focused image is used to detect contaminations on the surface of the unpatterned object.

24. The method of claim 22, further comprising classifying defects into phase defects and surface contamination defects based on comparison of the two initial images.

25. The method of claim 19, wherein constructing the resultant image comprises summing up the two initial images.

26. The method of claim 1, further comprising performing additional inspection passes of the surface of the unpatterned object and constructing additional resultant images that are combined with the resultant image to increase a signal-to-noise ratio.

27. The method of claim 1, wherein the illuminating light beam is focused onto the surface of the unpatterned object at a substantially normal angle, and wherein the illuminating light beam and the reflected light beam share their paths.

28. The method of claim 1, wherein the illuminating light beam is focused onto the surface of the unpatterned object at an oblique angle, and wherein the illuminating light beam and the reflected light beam do not share their paths.

29. The method of claim 28, further comprising attenuating a zero order component of the reflected light beam.

30. The method of claim 29, further comprising shifting a phase of the zero order component of the reflected light beam using an imaging aperture to improve the contrast and a signal-to-noise ratio.

31. A system for inspecting surface unevenness defects of less than about 10 nanometers in depth on a surface of an unpatterned object, the system comprising:

a laser for generating an illuminating light beam having a wavelength less than about 250 nanometers;

a set of optical elements with a partial coherence sigma to between about 0.15 to 0.5 for focusing the illuminating light beam onto the surface of the unpatterned object within a focus range of between about -3 to +3 depth of field (DOF);

a stage for moving the unpatterned object with respect to the illuminating light beam to inspect the surface of the unpatterned object;

a time delay integration (TDI) detector for capturing a reflected light beam reflected from the surface in response to the illuminating beam; and

a computer system comprising at least one memory and at least one processor for, based on the reflected light beam, constructing a resultant image and analyzing the resultant image to identify the surface unevenness defects.

CLAIMS

1. A method for inspecting phase defects and/or particles on a surface of an unpatterned object, the method comprising:

generating an illuminating light beam

passing the illuminating light beam through a set of optical elements with a partial coherence sigma to between about 0.15 and 0.5;

focusing the illuminating light beam onto the surface of the unpatterned object at a predetermined defocus range;

inspecting the surface of the unpatterned object with the illuminating light beam at the predetermined defocus range so that a reflected light beam reflects from the surface; and

based on the reflected light beam at the predetermined defocus range, constructing and analyzing a resultant image to identify the phase defects so as to distinguish between pit defects and bump defects.

2. The method of claim **1**, wherein the phase defects are less than about 10 nanometers in height and less than about 200 nanometers in a full width at half maximum (FWHM).

3. The method of claim **1**, wherein the phase defects are less than about 2 nanometers in height and less than about 100 nanometers in FWHM.

4. The method of claim **1**, wherein the predetermined defocus range includes a first sub-range that is between about +1 and +3 depth of field (DOF) and a second sub-range that is between about −1 and −3 DOF.

5. The method of claim **1**, wherein the resultant image comprises applying a filter to the resultant image or a detected signal generated from the reflected light beam so as to maximize a signal-to-noise (SNR) ratio in the resultant image or detected signal.

6. The method of claim **1**, further comprising applying a correction factor to remove a systematic noise comprising TDI calibration effects from the resultant image.

7. The method of claim **6**, wherein the correction factor is determined and applied during inspecting from initial capturing of the reflected light beam.

8. The method of claim **6**, wherein the correction factor is determined from intensity variations of a reflected light.

9. The method of claim **1**, wherein analyzing the resultant image comprises applying a threshold signal value of at least about 7 to detect phase defects.

10. The method of claim **1**, wherein the unpatterned object comprises an Extreme Ultraviolet Mask (EUV) blank.

11. The method of claim **1**, wherein the unpatterned object is a transmissive object.

12. The method of claim **1**, wherein the surface of the unpatterned object comprises quartz or an anti-reflective coating (ARC).

13. The method of claim **1**, wherein constructing and analyzing the resultant image comprises capturing reflected light with a dual-field TDI detector configured to construct two initial images of the surface of an unpatterned object.

14. The method of claim **13**, wherein the two initial images are constructed for two different defocus values.

15. The method of claim **14**, wherein the two different defocus values are opposite in sign.

16. The method of claim **14**, wherein the two initial images comprise a focused image constructed for a DOF of about zero.

17. The method of claim **16**, wherein the focused image is used to detect contaminations on the surface of the unpatterned object.

18. The method of claim **16**, further comprising classifying defects into phase defects and surface contamination defects based on comparison of the two initial images.

19. The method of claim **13**, wherein constructing the resultant image comprises summing up the two initial images.

20. The method of claim **1**, further comprising performing additional inspection passes of the surface of the unpatterned object and constructing additional resultant images that are combined with the resultant image to increase a signal-to-noise ratio.

21. The method of claim **1**, wherein the illuminating light beam is focused onto the surface of the unpatterned object at a substantially normal angle, and wherein the illuminating light beam and the reflected light beam share their paths.

22. The method of claim **1**, wherein the illuminating light beam is focused onto the surface of the unpatterned object at an oblique angle, and wherein the illuminating light beam and the reflected light beam do not share their paths, the method further comprising:

attenuating a zero order component of the reflected light beam;

shifting a phase of the zero order component of the reflected light beam using an imaging aperture to improve the contrast and a signal-to-noise ratio.

23. The method of claim **1**, wherein the illuminating light beam has a wavelength in the deep UV or an extreme UV range.

24. A system for inspecting surface unevenness defects of less than about 10 nanometers in depth on a surface of an unpatterned object, the system comprising:

a laser for generating an illuminating light beam;

a set of optical elements with a partial coherence sigma to between about 0.15 to 0.5 for focusing the illuminating light beam onto the surface of the unpatterned object within a focus range of between about −3 to +3 depth of field (DOF), including a defocused value;

a stage for moving the unpatterned object with respect to the illuminating light beam to inspect the surface of the unpatterned object;

a time delay integration (TDI) detector for capturing a reflected light beam reflected from the surface in response to the illuminating beam; and

a computer system comprising at least one memory and at least one processor for causing the set of optical elements to focus the illuminating light beam onto the surface of the unpatterned object at a predetermined defocus range and, based on the reflected light beam at the predetermined defocus range, constructing a resultant image and analyzing the resultant image to identify the surface unevenness defects so as to distinguish between pit defects and bump defects.

25. The system of claim **24**, wherein the unevenness defects comprise phase defects that are less than about 10 nanometers in height and less than about 200 nanometers in a full width at half maximum (FWHM).

26. The system of claim **24**, wherein the predetermined defocus range includes a first and second predetermined defocus range wherein the first predetermined defocus range is between about +1 and +3 depth of field (DOF) and the second predetermined defocus range is between about −1 and −3 DOF.

27. The system of claim **24**, wherein the predetermined defocus range includes two different opposite sign defocus values.

28. The system of claim **24**, wherein the predetermined defocus range includes a defocus value and a focused value of about zero.

29. The system of claim **24**, wherein the computer system is further configured for constructing and analyzing two initial images.

30. The system of claim **29**, wherein the two initial images are constructed from the illumination light beam being focused at two different defocus values.

31. The system of claim **30**, wherein the two different defocus values are opposite in sign.

32. The system of claim **29**, wherein the two initial images are constructed from the illumination light beam being focused at an unfocused value and a focused value having a depth of field of about zero.

33. The system of claim **32**, further comprising classifying defects into phase defects and surface contamination defects based on comparison of the two initial images.

34. The system of claim **24**, wherein the illuminating light beam has a wavelength in the deep UV or an extreme UV range.

35. The system of claim **24**, wherein constructing a resultant image comprises applying a filter to the resultant image or a detected signal generated from the reflected light beam so as to maximize a signal-to-noise (SNR) ratio in the resultant image or detected signal.

36. The system of claim **35**, wherein applying the filter comprises applying a matched filter.

37. The method of claim **24**, wherein applying a filter comprises applying a matched filter.