What is claimed is:

1. A method of measuring at least one shape-based property of a specularly reflective surface, comprising:

directing a collimated laser beam to a sample surface;

reflecting the collimated laser beam from the sample surface to form a reflected laser beam that includes shape information of the specularly reflective surface;

directing a first portion of the reflected laser beam to a first pair of axially spaced apart gratings having a first orientation and forming two first diffraction components, and combining the two first diffraction components to form a first interference pattern on a first image sensor;

directing a second portion of the reflected laser beam to a second pair of axially spaced apart gratings having a second orientation orthogonal to the first orientation and forming two second diffraction components and combining the two second diffraction components to form a second interference pattern on a second image sensor; and

processing the first and second interference patterns to determine the at least one shape-based property of the specularly reflective surface;

wherein:

directing the collimated laser beam includes generating an initial laser beam from a laser source and passing the initial laser beam through a first beam expander to form a first expanded laser beam and then through a second beam expanding optical system to form a second expanded laser beam, the second beam expanding optical system having an expansion factor;

the reflected laser beam contains a reflected wave-front error signal equal to twice the 3D-deformation of the wafer surface slope distribution; and

the reflected laser beam passes through the second beam expanding optical system in a direction opposite the first expanded laser beam to

contract the reflected laser beam so as to contain an enhanced reflected wave-front error signal equal to the reflected wave-front error signal multiplied by the expansion factor of the second beam expanding optical system.

2. A method of measuring at least one shape-based property of a specularly reflective surface, comprising:

directing a collimated laser beam to a sample surface;

reflecting the collimated laser beam from the sample surface to form a reflected laser beam that includes shape information of the specularly reflective surface;

directing a first portion of the reflected laser beam to a first pair of axially spaced apart gratings having a first orientation and forming two first diffraction components, and combining the two first diffraction components to form a first interference pattern on a first image sensor;

directing a second portion of the linearly polarized reflected laser beam to a second pair of axially spaced apart gratings having a second orientation orthogonal to the first orientation and forming two second diffraction components and combining the two second diffraction components to form a second interference pattern on a second image sensor; and

processing the first and second interference patterns to determine the at least one shape-based property of the specularly reflective surface;

wherein combining the two first diffraction components includes passing the two first diffraction components through a first Fourier aperture using a first relay lens system, and wherein combining the two second diffraction components includes passing the two second diffraction components through a second Fourier aperture using a second relay lens system.

3. A method of measuring at least one shape-based property of a specularly reflective surface, comprising:

directing a collimated laser beam to a sample surface;

reflecting the collimated laser beam from the sample surface to form a reflected laser beam that includes shape information of the specularly reflective surface;

directing a first portion of the reflected laser beam to a first pair of axially spaced apart gratings having a first orientation and forming two first diffraction components, and combining the two first diffraction components to form a first interference pattern on a first image sensor;

directing a second portion of the linearly polarized reflected laser beam to a second pair of axially spaced apart gratings having a second orientation orthogonal to the first orientation and forming two second diffraction components and combining the two second diffraction components to form a second interference pattern on a second image sensor;

processing the first and second interference patterns to determine the at least one shape-based property of the specularly reflective surface; and

controlling a first magnification of the first portion of the linearly polarized reflected laser beam and controlling a second magnification of the second portion of the linearly polarized reflected laser beam so that the first interference pattern formed on the first image sensor has a same size as the second interference pattern formed on the second image sensor.

4. A method of measuring at least one shape-based property of a specularly reflective surface, comprising:

directing a collimated laser beam to a sample surface;

reflecting the collimated laser beam from the sample surface to form a reflected laser beam that includes shape information of the specularly reflective surface;

directing a first portion of the reflected laser beam to a first pair of axially spaced apart gratings having a first orientation and forming two first diffraction components, and combining the two first diffraction components to form a first interference pattern on a first image sensor;

directing a second portion of the linearly polarized reflected laser beam to a second pair of axially spaced apart gratings having a second orientation orthogonal to the first orientation and forming two second diffraction components and combining the two second diffraction components to form a second interference pattern on a second image sensor; and

processing the first and second interference patterns to determine the at least one shape-based property of the specularly reflective surface;

wherein the first image sensor has first pixels and is combined with a first camera lens to form a first camera, wherein the second image sensor has second pixels and is combined with a second camera lens to form a second camera, and wherein each of the first and second cameras has multi-axis position control to perform surface-to-sensor pixel matching between the sample surface and the first and second pixels of the first and second image sensors.

5. A method of measuring at least one shape-based property of a specularly reflective surface, comprising:

directing a collimated laser beam to a sample surface;

reflecting the collimated laser beam from the sample surface to form a reflected laser beam that includes shape information of the specularly reflective surface;

directing a first portion of the reflected laser beam to a first pair of axially spaced apart gratings having a first orientation and forming two first diffraction components, and combining the two first diffraction components to form a first interference pattern on a first image sensor;

directing a second portion of the linearly polarized reflected laser beam to a second pair of axially spaced apart gratings having a second orientation orthogonal to the first orientation and forming two second diffraction components and combining the two second diffraction components to form a second interference pattern on a second image sensor;

processing the first and second interference patterns to determine the at least one shape-based property of the specularly reflective surface;

directing the two first diffraction components through a first adjustable aperture having an adjustable size and adjustable axial position;

directing the two second diffraction components through a second adjustable aperture having an adjustable size and adjustable axial position; and

adjusting at least one of the size and axial position of the first and second adjustable apertures to block diffraction orders other than two first diffraction orders and two second diffraction orders, respectively.

6. The method according to any one of claims 1 through 5, wherein directing the first and second portions of the reflected laser beam includes using a beam splitter to send the first and second portions of the reflected laser beam to respective first and second relay assemblies.

7. The method according to any one of claims 1 through 5, wherein the first and second portions of the reflected laser beam have substantially the same intensity.

8. The method according to any one of claims 2 through 5, wherein:

directing the collimated laser beam includes generating an initial laser beam from a laser source and passing the initial laser beam through a first beam expander to form a first expanded laser beam and then through a beam expanding optical system to form a second expanded laser beam;

the reflected laser beam contains a reflected wave-front error signal equal to twice the 3D-deformation of the wafer surface slope distribution; and

the reflected laser beam passes through the second beam expanding optical system in a direction opposite the first expanded laser beam to contract the reflected laser beam so as to contain an enhanced reflected wave-front error signal equal to the reflected wave-front error signal multiplied by the expansion factor of the second beam expanding optical system.

9. The method according to any one of claims 1 through 5, wherein the initial laser beam and the first expanded laser beam are linearly polarized and including passing the first expanded laser beam through a quarter-wave retardation plate to form a circularly polarized collimated laser beam.

10. The method according to claim 9, wherein the reflected laser beam has a circular polarization and converting the reflected laser beam to the linearly polarized reflected laser beam includes passing the reflected laser beam through the quarter-wave retardation plate.

11. The method according to any one of claims 1, 3, 4 and 5, wherein combining the two first diffraction components includes passing the two first diffraction components through a first Fourier aperture using a first relay lens system, and wherein combining the two second diffraction components includes passing the two second diffraction components through a second Fourier aperture using a second relay lens system.

12. The method according to any of claims 1 through 11, wherein the collimated laser beam has a diameter of between 300 mm and 450 mm.

13. The method according to any one of claims 1 through 5, wherein the collimated laser beam is formed from an initial laser beam emitted by a helium-neon laser.

14. The method according to any one of claims 1 through 5, wherein the first and the second pairs of axially spaced apart gratings each consist of phase gratings.

15. The method according to any one of claims 1, 2, 4 and 5, further comprising controlling a first magnification of the first portion of the linearly polarized reflected laser beam and controlling a second magnification of the second portion of the linearly polarized reflected laser beam so that the first

interference pattern formed on the first image sensor has a same size as the second interference pattern formed on the second image sensor.

16. The method according to any one of claims 1, 2, 4 and 5, where the first image sensor has first pixels and is combined with a first camera lens to form a first camera, wherein the second image sensor has second pixels and is combined with a second camera lens to form a second camera, and wherein each of the first and second cameras has multi-axis position control to perform surface-to-sensor pixel matching between the sample surface and the first and second pixels of the first and second image sensors.

17. The method according to any one of claims 1 through 5, wherein the at least one shape-based property includes a height difference between two locations on the sample surface, a slope and a curvature.

18. The method according to any one of claims 1 through 4, further comprising:
    directing the two first diffraction components through a first adjustable aperture having an adjustable size and adjustable axial position;
    directing the two second diffraction components through a second adjustable aperture having an adjustable size and adjustable axial position; and
    adjusting at least one of the size and axial position of the first and second adjustable apertures to block diffraction orders other than two first diffraction orders and two second diffraction orders, respectively.

19. A system for measuring at least one shape-based property of a sample having a surface that is specularly reflective, comprising:
    a laser source that emits a first laser beam;
    a beam splitter arranged to transmit the first laser beam;
    a beam expanding optical system that receives and directs the first laser beam to the surface of sample to form a reflected laser beam that includes shape information about the surface of sample, wherein the reflected laser beam

exits the beam expanding optical system and reflects from the beam splitter to form a second laser beam;

a beam splitter arranged to pass and reflect respective first and second portions of the second laser beam;

a first relay assembly arranged to receive and direct the first portion of the second laser beam to a first pair of axially spaced apart gratings having a first orientation and that form two first diffraction components, wherein the two first diffraction components are combined to form a first interference pattern on a first image sensor;

a second relay assembly arranged to receive and direct the second portion of the second laser beam to a second pair of axially spaced apart gratings having a second orientation to form two second diffraction components, wherein the two second diffraction components are combined to form a second interference pattern on a second image sensor;

a processor configured to process the first and second interference patterns to determine the at least one shape-based property of the sample having the surface that is specularly reflective;

a first camera lens that in combination with the first image sensor defines a first camera, wherein the first image sensor has first pixels;

a second camera lens that in combination with the second image sensor defines a second camera, wherein the second image sensor has second pixels;

wherein each of the first and second cameras has multi-axis position control to perform surface-to-sensor pixel matching between the surface of sample and the first and second pixels of the first and second image sensors.

20. A system for measuring at least one shape-based property of a sample having a surface that is specularly reflective, comprising:

a laser source that emits a first laser beam;

a beam splitter arranged to transmit the first laser beam;

a beam expanding optical system that receives and directs the first laser beam to the surface of sample to form a reflected laser beam that includes shape information about the surface of sample, wherein the reflected laser beam exits the beam expanding optical system and reflects from the beam splitter to form a second laser beam;

a beam splitter arranged to pass and reflect respective first and second portions of the second laser beam;

a first relay assembly arranged to receive and direct the first portion of the second laser beam to a first pair of axially spaced apart gratings having a first orientation and that form two first diffraction components, wherein the two first diffraction components are combined to form a first interference pattern on a first image sensor;

a second relay assembly arranged to receive and direct the second portion of the second laser beam to a second pair of axially spaced apart gratings having a second orientation to form two second diffraction components, wherein the two second diffraction components are combined to form a second interference pattern on a second image sensor; and

a processor configured to process the first and second interference patterns to determine the at least one shape-based property of the sample having the surface that is specularly reflective;

wherein:

the beam expanding optical system has an expansion factor;

the reflected laser beam contains a reflected laser beam contains a reflected wave-front error signal equal to twice the 3D-deformation of the wafer surface slope distribution; and

when the reflected laser beam passes through the beam expanding optical system in a direction opposite the first laser beam, the reflected laser beam contracts so as to contain an enhanced reflected wave-front error signal equal to the reflected wave-front error signal multiplied by the expansion factor of the beam expanding optical system.

21. A system for measuring at least one shape-based property of a sample having a surface that is specularly reflective, comprising:

a laser source that emits a first laser beam;

a beam splitter arranged to transmit the first laser beam;

a beam expanding optical system that receives and directs the first laser beam to the surface of sample to form a reflected laser beam that includes shape information about the surface of sample, wherein the reflected laser beam exits the beam expanding optical system and reflects from the beam splitter to form a second laser beam;

a beam splitter arranged to pass and reflect respective first and second portions of the second laser beam;

a first relay assembly arranged to receive and direct the first portion of the second laser beam to a first pair of axially spaced apart gratings having a first orientation and that form two first diffraction components, wherein the two first diffraction components are combined to form a first interference pattern on a first image sensor, the first relay assembly including a first adjustable aperture through which the two first diffraction components pass, wherein the first adjustable aperture is selected and adjusted to block all unwanted pairs of diffraction components in the two first diffraction components;

a second relay assembly arranged to receive and direct the second portion of the second laser beam to a second pair of axially spaced apart gratings having a second orientation to form two second diffraction components, wherein the two second diffraction components are combined to form a second interference pattern on a second image sensor, the second relay assembly including a second adjustable aperture through which the two second diffraction components pass, wherein the first adjustable aperture is selected and adjusted to block all unwanted pairs of diffraction components in the two first diffraction components; and

a processor configured to process the first and second interference patterns to determine the at least one shape-based property of the sample having the surface that is specularly reflective.

22. The system according to any one of claims 19, 20, and 21, wherein the at least one shape-based property includes a height difference between two locations on the surface of sample, a slope and a curvature.

23. The system according to any one of claims 19, 20, and 21, wherein the surface of sample has a diameter and wherein the beam-expanding optical system is configured to expand the first laser beam to have a diameter equal to or greater than the diameter of the surface of sample.

24. The system according to any one of claims 19, 20, and 21, wherein the first and second pairs of axially spaced apart gratings are each formed by holographic gratings.

25. The system according to any one of claims 19, 20, and 21, wherein the first and second relay assemblies each have an adjustable magnification.

26. The system according to any one of claims 19, 20, and 21, wherein the first relay assembly includes a compensating plate.

27. The system according to any one of claims 19, 20, and 21, further comprising a beam expander operably arranged between the laser source and the polarizing beam splitter and that is configured to expand the first laser beam.

28. The system according to any one of claims 19, 20, and 21, wherein the beam splitter is a 50:50 beam splitter.

29. The system according to either of claims 20 and 21, further comprising:

a first camera lens that in combination with the first image sensor defines a first camera, wherein the first image sensor has first pixels;

a second camera lens that in combination with the second image sensor defines a second camera, wherein the second image sensor has second pixels;

wherein each of the first and second cameras has multi-axis position control to perform surface-to-sensor pixel matching between the surface of sample and the first and second pixels of the first and second image sensors.

30. The system according to any one of claims 19 and 20, further comprising:

a first adjustable aperture operably arranged in the first relay assembly between the first image sensor and the first pair of axially spaced apart gratings, the first adjustable aperture having an adjustable size and an adjustable axial position; and

a second adjustable aperture operably arranged in the second relay assembly between the second image sensor and the second pair of axially spaced apart grating, the second adjustable aperture having an adjustable size and an adjustable axial position.