CLAIMS

1. A metrology system comprising:

(a) an illumination sub-system comprising:

(i) one or more illumination sources; and

(ii) one or more illumination optics to illuminate a metrology target on a sample with illumination having a symmetric off-axis illumination profile,

(1) wherein the symmetric off-axis illumination profile is symmetric along one or more measurement directions;

(2) wherein the illumination sub-system provides the illumination from opposing angles in the symmetric off-axis illumination profile at least one of simultaneously or sequentially; and

(3) wherein the metrology target includes a first periodic structure on a first layer of the sample and a second periodic structure on a second layer of the sample;

(b) an imaging sub-system comprising:

(i) an objective lens; and

(ii) a detector to collect light from the metrology target with the objective lens and generate one or more images of the metrology target,

(1) wherein a collection pupil of the imaging sub-system exclusively passes two non-zero diffraction orders of a common sign from any of the opposing angles of the symmetric off-axis illumination profile to the detector for generating the one or more images of the metrology target; and

(2) wherein a combined distribution in the collection profile associated with the two non-zero diffraction orders from the opposing angles of the symmetric off-axis illumination profile collected at least one of simultaneously or sequentially is symmetric; and

(c) a controller communicatively coupled to the imaging sub-system, wherein the controller includes one or more processors configured to execute program instructions causing the one or more processors to:

(i) receive the one or more images of the metrology target from the imaging sub-system associated with the illumination of the metrology target with the symmetric off-axis illumination profile; and

(ii) determine an overlay error indicative of alignment between the first layer and the second layer based on the one or more images.

2. The metrology system of claim 1, wherein the illumination sub-system provides the illumination from the opposing angles in the symmetric off-axis illumination profile simultaneously, wherein the symmetric collection profile is generated simultaneously.

3. The metrology system of claim 1, wherein the illumination sub-system provides the illumination from the opposing angles in the symmetric off-axis illumination profile sequentially, wherein the symmetric collection profile is generated sequentially and is associated with combined collection profiles from the illumination with the opposing angles in the symmetric off-axis illumination profile.

4. The metrology system of claim 1, wherein the symmetric off-axis illumination profile comprises:

at least one of a dipole illumination profile, a quadrupole illumination profile, or an annular illumination profile.

5. The metrology system of claim 1, wherein at least one of a wavelength of the illumination, one or more illumination angles in the symmetric off-axis illumination profile, or periods of the first or second periodic structures are selected to provide a symmetric intensity distribution in the collection pupil of the imaging sub-system.

6. The metrology system of claim 1, wherein the two non-zero diffraction orders from each of the opposing angles of the symmetric off-axis illumination profile comprise:

non-zero diffraction orders based on reflection from the metrology target.

7. The metrology system of claim 6, wherein the illumination sub-system includes an illumination lens to direct the illumination in the symmetric off-axis illumination profile to the metrology target at one or more angles outside a numerical aperture of the objective lens.

8. The metrology system of claim 6, wherein the illumination sub-system directs the illumination beam to the metrology target through the objective lens.

9. The metrology system of claim 8, wherein the metrology system further comprises:

one or more stops to block at least zero-order diffraction from the light from the metrology target collected by the objective lens.

10. The metrology system of claim 1, wherein the two non-zero diffraction orders from each of the opposing angles of the symmetric off-axis illumination profile comprise:

non-zero diffraction orders based on transmission through the metrology target.

11. The metrology system of claim 1, wherein the two non-zero diffraction orders of the opposing angles of the symmetric off-axis illumination profile comprise:

first-order diffraction and second-order diffraction.

12. The metrology system of claim 1, wherein at least one of a spatial coherence or a temporal coherence of the illumination in the symmetric off-axis illumination profile is selected to provide that the two non-zero diffraction orders from each of the opposing angles of the symmetric off-axis illumination profile are fully within the collection pupil of the imaging sub-system.

13. The metrology system of claim 1, wherein the first layer and the second layer are disposed on a common wafer.

14. The metrology system of claim 1, wherein the sample includes a first wafer and a second wafer bonded at an interface, wherein the first layer is on the first wafer, wherein the second layer is on the second wafer.

15. The metrology system of claim 1, wherein the first periodic structure and the second periodic structure have a common period.

16. A metrology system comprising:

(a) a multi-channel illumination source comprising one or more illumination sources configured to generate two or more illumination beams in two or more illumination channels,

(i) wherein the two or more illumination beams are arranged to illuminate a metrology target on a sample in a symmetric off-axis illumination profile;

(ii) wherein the two or more illumination beams are oriented to be symmetric along one or more measurement directions;

(iii) wherein the two or more illumination beams illuminate the metrology target with the symmetric off-axis illumination profile at least one of simultaneously or sequentially; and

(iv) wherein the metrology target includes a first periodic structure on a first layer of the sample and a second periodic structure on a second layer of the sample;

(b) an imaging sub-system comprising:

(i) an objective lens configured to collect light from the metrology target in response to the two or more illumination beams; and

(ii) a detector configured to generate one or more images of the metrology target,

(1) wherein a collection pupil of the imaging sub-system exclusively passes two non-zero diffraction orders of a common sign from any of the two or more illumination beams to the detector for generating the one or more images of the metrology target; and

(2) wherein a combined distribution in the collection pupil associated with the two non-zero diffraction orders from the opposing angles of the symmetric off-axis illumination profile collected at least one of simultaneously or sequentially is symmetric; and

(c) a controller communicatively coupled to the imaging sub-system, wherein the controller includes one or more processors configured to execute program instructions causing the one or more processors to:

(i) receive the one or more images of the metrology target from the imaging sub-system; and

(ii) determine an overlay error indicative of alignment between the first layer and the second layer based on the one or more images.

17. The metrology system of claim 16, wherein the two or more illumination beams illuminate the metrology target with the symmetric off-axis illumination profile simultaneously, wherein the symmetric collection profile is generated simultaneously.

18. The metrology system of claim 16,

wherein the two or more illumination beams illuminate the metrology target with the symmetric off-axis illumination profile sequentially; and

wherein the symmetric collection profile is generated sequentially and is associated with combined collection profiles from illumination with illumination beams of the two or more illumination beams at opposing angles.

19. The metrology system of claim 16, wherein at least some of the two or more illumination beams have different wavelengths.

20. The metrology system of claim 16, wherein the symmetric off-axis illumination profile comprises:

at least one of a dipole illumination profile, a quadrupole illumination profile, or an annular illumination profile.

21. The metrology system of claim 16, wherein the two non-zero diffraction orders from each of the two or more illumination beams comprise:

non-zero diffraction orders based on reflection from the metrology target.

22. The metrology system of claim 21, wherein the two or more illumination beams illuminate the metrology target with the symmetric off-axis illumination profile outside a numerical aperture of the objective lens.

23. The metrology system of claim 21, wherein the two or more illumination beams illuminate the metrology target with the symmetric off-axis illumination profile through the objective lens.

24. The metrology system of claim 23, wherein the metrology system further comprises:

one or more stops to block at least zero-order diffraction from the light from the metrology target collected by the objective lens.

25. The metrology system of claim 16, wherein the two non-zero diffraction orders from each of the two or more illumination beams comprise:

non-zero diffraction orders based on transmission through the metrology target.

26. The metrology system of claim 16, wherein the two non-zero diffraction orders from each of the two or more illumination beams comprise:

first-order diffraction and second-order diffraction.

27. The metrology system of claim 16, wherein at least one of a spatial coherence or a temporal coherence of illumination in the symmetric off-axis illumination profile is selected to provide that the two non-zero diffraction orders from each of the two or more illumination beams are fully within the collection pupil of the imaging sub-system.

28. The metrology system of claim 16, wherein the first layer and the second layer are disposed on a common wafer.

29. The metrology system of claim 16, wherein the sample includes a first wafer and a second wafer bonded at an interface, wherein the first layer is on the first wafer, wherein the second layer is on the second wafer.

30. The metrology system of claim 16, wherein the first periodic structure and the second periodic structure have a common period.

31. A metrology method comprising:

(a) illuminating a metrology target on a sample with illumination having a symmetric off-axis illumination profile, wherein the symmetric off-axis illumination profile is symmetric along one or more measurement directions,

(i) wherein the symmetric off-axis illumination profile is directed to the metrology target at least one of simultaneously or sequentially; and

(ii) wherein the metrology target includes a first periodic structure on a first layer of the sample and a second periodic structure on a second layer of the sample;

(b) generating one or more images of the metrology target to a detector,

(i) wherein a collection pupil prior to the detector exclusively passes two non-zero diffraction orders of a common sign from any of the opposing angles of the symmetric off-axis illumination profile to the detector for generating the one or more images of the metrology target; and

(ii) wherein a combined distribution in the collection pupil associated with the two non-zero diffraction orders from the opposing angles of the symmetric off-axis illumination profile collected at least one of simultaneously or sequentially is symmetric; and

(c) determining, with one or more processors, an overlay error indicative of alignment of the first layer and the second layer based on the one or more images.