

CLAIMS

What is claimed:

1. A metrology system comprising:

an illumination sub-system configured to illuminate 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, wherein the illumination sub-system provides illumination from opposing angles in the symmetric off-axis illumination profile at least one of simultaneously or sequentially, 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;

an imaging sub-system configured to collect light from the metrology target with an objective lens and generate one or more images of the metrology target formed using two non-zero diffraction orders from each point of the symmetric off-axis illumination profile; and

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:

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

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 illumination from opposing angles in the symmetric off-axis illumination profile simultaneously.

3. The metrology system of claim 1, wherein the illumination sub-system provides illumination from opposing angles in the symmetric off-axis illumination profile sequentially.

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 a collection pupil of the imaging sub-system.

6. The metrology system of claim 1, wherein the two non-zero diffraction orders from each point 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 point 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 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 point of the symmetric off-axis illumination profile are fully within a 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 multi-channel illumination source configured to generate two or more illumination beams, wherein the two or more illumination beams are arranged to illuminate a metrology target on a sample in a symmetric off-axis illumination profile, wherein the two or more illumination beams are oriented to be symmetric along one or more measurement directions, 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, 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;

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

an imaging sub-system configured to generate one or more images of the metrology target based on two non-zero diffraction orders from each of the two or more illumination beams;

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:

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

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.

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.

19. The metrology system of claim 16, wherein at least some 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 point of the symmetric off-axis illumination profile 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 point of the symmetric off-axis illumination profile 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 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 the illumination in the symmetric off-axis illumination profile is selected to provide that the two non-zero diffraction orders from each point of the symmetric off-axis illumination profile are fully within a 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:

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

generating one or more images of the metrology target based on two non-zero diffraction orders from each point of the symmetric off-axis illumination profile in response to the illumination with the symmetric off-axis illumination profile; and

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