

What is claimed:

1. An apparatus for simultaneous dark field and differential interference contrast inspection comprising:

- one or more illumination sources;
- a sample stage configured to secure a sample;
- a first sensor;
- a second sensor; and
- an optical sub-system comprising:
 - an objective;

- one or more optical elements arranged to direct, through the objective, illumination from the one or more illumination sources to a surface of the sample, wherein the objective is configured to collect a collected signal from the surface of the sample, wherein the collected signal includes at least one of a scattering-based signal and a phase-based signal from the sample; and

- one or more separation optical elements arranged to spatially separate the collected signal into a dark field signal and a differential interference contrast signal by directing the dark field signal along a dark field path to the first sensor and the differential interference contrast signal along a differential interference contrast path to the second sensor, wherein the one or more separation optical elements include a reflective pupil mask arranged to spatially separate the collected signal into a dark field signal and a differential interference contrast signal based on a selected NA threshold.

2. The apparatus of claim 1, further comprising:

- a controller communicatively coupled to the first sensor and the second sensor, wherein the controller is configured to:

- receive one or more measurements of the dark field signal associated with the sample from the first sensor; and
- receive one or more measurements of the differential interference contrast signal associated with the sample from the second sensor.

3. The apparatus of claim 2, wherein the controller is further configured to perform a data fusion process to characterize one or more portions of the sample, simultaneously, with the received dark field signal and the received differential interference contrast signal.

4. The apparatus of claim 2, wherein the controller is further configured to perform a data fusion process to characterize one or more portions of the sample, independently, with at least one of the received dark field signal or the received differential interference contrast signal.

5. The apparatus of claim 1, wherein the reflective pupil mask of the optical sub-system comprises:

- a mirrored pupil mask configured to reflect illumination having an NA larger than a selected NA threshold along a dark field path, the mirrored pupil mask further configured to transmit illumination having an NA smaller than the selected NA threshold along a differential interference contrast path.

6. The apparatus of claim 1, wherein the reflective pupil mask of the optical sub-system comprises:

- at least a mirrored pupil mask configured to reflect illumination having an NA smaller than a selected NA threshold along a dark field path, the mirrored pupil mask further configured to transmit illumination having an NA larger than the selected NA threshold along a differential interference contrast path.

7. The apparatus of claim 1, wherein the one or more separation optical elements of the optical sub-system comprise:

- a beam splitter configured to separate the collected signal into a first portion directed along the dark field path to the first sensor and a second portion directed along the differential interference contrast path to the second sensor.

8. The apparatus of claim 1, wherein the one or more illumination sources comprise:

- one or more lasers.

9. The apparatus of claim 1, wherein the first sensor comprises:

- a one-dimensional sensor.

10. The apparatus of claim 1, wherein the second sensor comprises:

- a two-dimensional sensor.

11. The apparatus of claim 1, wherein the apparatus is configured as a wafer inspection tool.

12. The apparatus of claim 1, wherein the apparatus is configured as a microscope for a biological sample.

13. An apparatus for simultaneous dark field and differential interference contrast inspection comprising:

- one or more illumination sources;

- a sample stage configured to secure a sample; and

- an optical sub-system comprising:

 - an objective;

 - a mirrored pupil mask configured to transmit illumination having an NA below a selected NA threshold;

 - one or more optical elements arranged to direct illumination having an NA below the selected NA threshold through the mirrored pupil mask, wherein

the one or more optical elements are further configured to direct illumination transmitted through the mirrored pupil mask through the objective and to a surface of the sample,
wherein the objective is configured to collect a collected signal from the surface of the sample, wherein the collected signal includes at least one of a scattering signal and a phase signal from the sample,
wherein the mirrored pupil mask is further configured to spatially separate the collected signal into a dark field signal and a differential interference contrast signal by reflecting a portion of the collected illumination having an NA above the selected NA threshold along a dark field path to a first sensor and transmitting a portion of the collected illumination having an NA below the selected NA threshold along the differential interference contrast path to a second sensor.

14. The apparatus of claim **13**, wherein the one or more illumination sources comprise:

one or more lasers.

15. The apparatus of claim **13**, wherein the first sensor comprises:

a one-dimensional sensor.

16. The apparatus of claim **13**, wherein the second sensor comprises:

a two-dimensional sensor.

17. The apparatus of claim **13**, wherein the apparatus is configured as a wafer inspection tool.

18. The apparatus of claim **13**, wherein the apparatus is configured as a microscope for a biological sample.

19. An apparatus for simultaneous dark field and differential interference contrast inspection comprising:

one or more illumination sources;

a sample stage configured to secure a sample; and

an optical sub-system comprising:

an objective;

- one or more optical elements configured to direct illumination through the objective and to a surface of the sample, wherein the objective is configured to collect a collected signal from the surface of the sample, wherein the collected signal includes at least one of a scattering signal and a phase signal from the sample,
- a beam splitter configured to direct a first portion of the collected illumination along a dark field path, wherein the beam splitter is further configured to transmit a second portion of the collected illumination along the differential interference contrast path;
- a pupil block disposed along the dark field path and configured to block illumination having an NA below a selected NA threshold; and
- a pupil mask disposed along the differential contrast interference path and configured to block illumination having an NA above the selected NA threshold;
- a first sensor configured to collect illumination transmitted by the pupil block of the dark field path; and
- a second sensor configured to collect illumination transmitted by the pupil mask of the differential interference contrast path.
- 20.** The apparatus of claim **19**, wherein the one or more illumination sources comprise:
- one or more lasers.
- 21.** The apparatus of claim **19**, wherein the first sensor comprises:
- a one-dimensional sensor.
- 22.** The apparatus of claim **19**, wherein the second sensor comprises:
- a two-dimensional sensor.
- 23.** The apparatus of claim **19**, wherein the apparatus is configured as a wafer inspection tool.
- 24.** The apparatus of claim **19**, wherein the apparatus is configured as a microscope for a biological sample.