Claims

1. An inspection system with an adapted Michelson setup for detecting cracks on a surface of a workpiece, comprising:

an illumination module configured to generate fringe patterns in an image of the surface of the workpiece illuminated, wherein the illumination module includes an illumination source, the illumination source generates the illumination;

an optical module, the optical module comprises an illumination collimator to collimate the illumination from the illumination source;

an image capture module configured to capture an image of the fringe patterns; and

a detection module configured to analyze and detect changes to the fringe patterns caused by height and planarity differences in the surface along and adjacent to a crack to indicate the presence of a crack.

2. The system of claim 1, wherein the detection module is further configured to determine a location and an extent of the crack, if present, by delineating the border between fringe pattern changes in the image of the workpiece.

3. The system of claim 1 or 2 wherein the adapted Michelson setup comprises:

a reference module, the reference module includes a reference mirror having high reflectivity and minimal aberrations;

a beam splitter assembly module comprising a primary beam splitter, wherein the primary beam splitter assembly is configured to direct the illumination into first and second illumination paths, wherein

the first illumination path is towards the reference mirror of the reference module,

the second illumination path is towards the surface of the workpiece to be inspected with minimal illumination deviation and distortion, and

wherein the surface of the workpiece and the reference mirror are configured with a relative distance between a center of reference mirror to a center of the primary beam splitter and the distance of the surface of the workpiece to the primary beam splitter such that reflected illuminations from the reference mirror and the surface of the workpiece maintains a constant phase difference and interfere constructively.

4. The system of claim 3 wherein the beam splitter assembly module comprises:

an illumination beam splitter, the illumination beam splitter is configured to receive illumination from the illumination module;

a primary beam splitter, wherein the beam splitter is configured to receive the illumination from the illumination beam splitter and directs the received illumination from the illumination beam splitter to the first and second illumination paths.

5. The system of any one of claims 1 to 4 wherein the illumination module of the adapted Michelson setup comprises an illumination source, the illumination source generates the illumination, wherein the illumination source is configured to emit illumination with a long coherent length having a wavelength within a range of about 380-950 nm which is optimized for inspecting a silicon-based workpiece without inducing transparency.

6. The system of any one of claims 1 to 5 wherein the optical module further comprises an illumination shaper lens assembly, the illumination shaper lens assembly is configured to transform the collimated illumination to a collimated illumination with a planar wavefront (transformed collimated illumination).

7. The system of any one of claims 1 to 6 wherein the image capture module comprises:

an image sensor with a predetermined resolution, sensitivity, and dynamic range; and

a telecentric lens, the telecentric lens provides a large field of view (FOV) and distortion-free imaging with minimal vignetting for inspecting the workpiece.

8. The system of any one of claims 1 to 7 wherein the illumination module comprises a LED diode coupled to a wavelength filter configurable to select a wavelength within a range of 380 nm to 950 nm.

9. The system of claim 8 comprises a planar platform for positioning the workpiece for inspecting the surface of the workpiece, wherein positioning the workpiece comprises positioning a tray holding a plurality of workpieces which are dies, wherein all workpieces of the tray are inspected to complete inspection of the workpieces of the tray.

10. The system of claim 9 wherein a processor automatically initiates the detection module to analyze the images for presence of cracks.

11. The system of claim 9 or 10 wherein positioning the workpiece comprises positioning a wafer, wherein the inspection system scans the surface of the whole wafer to complete inspecting the surface of the whole wafer.

12. The system of claim 11 wherein a processor automatically initiates the detection module to:

stitch images to form a stitched image of the surface of the whole wafer; and

analyze the stitched image to detect the presence of cracks.

13. An integrated inspection system for detecting surface irregularities on a surface of a workpiece comprising:

a Mode-1 inspection module comprising a Mode-1 illumination unit comprising a Mode-1 BF illuminator and Mode-1 DF illuminators configured to illuminate the surface of the workpiece on a planar platform with co-axial diffused bright (BF) illumination or darkfield (DF) illuminations respectively or a combination thereof to detect micron-sized surface irregularities on the surface of the workpiece to obtain Mode-1 images of the surface of the workpiece, wherein the surface irregularities include contaminates, cracks and grinding lines;

a Mode-2 inspection module comprising a Mode-2 BF illumination unit configured to illuminate the surface of the workpiece on the planar platform with a Mode-2 BF illumination to obtain Mode-2 images of the surface of the workpiece, a Mode-2 collimator for collimating the Mode-2 BF illumination to produce the collimated Mode-2 illumination to illuminate directed perpendicularly to the surface of the workpiece to detect micron-sized and submicron-sized surface irregularities;

a Mode-3 inspection module comprising a Mode-3 IR illumination unit configured to illuminate the surface of the workpiece on the planar platform with Mode-3 IR illumination to produce regular fringe patterns from the surface of at least one die, a Mode-3 collimator for collimating the Mode-3 IR illumination to produce the collimated Mode-3 IR illumination to illuminate the surface of the workpiece to obtain Mode-3 images of the surface of the workpiece, wherein changes in the fringe patterns are indicative of height and planarity differences between the surface along and adjacent to a crack which are crack characteristic of a crack's presence, thereby enabling the detection of the submicron crack and differentiating submicron cracks from grinding lines that lack the crack characteristic;

a beam splitter assembly module configured to split the illuminations from the Mode-1, Mode-2, or Mode-3 inspection modules, when operating in Mode-1, Mode-2 or Mode-3 inspection modes along first and second illumination paths, and

an image capture module for capturing Mode-1 images in Mode-1 inspection mode, Mode-2 images in Mode-2 inspection mode and Mode-3 images in Mode-3 inspection mode, wherein the image capture module comprises an image sensor with a predetermined resolution, sensitivity, and dynamic range.

14. The integrated inspection system of claim 13 further comprising:

a reference module comprising a reference mirror and a reference illumination absorber, wherein

the first illumination path is directed to the reference module,

the second illumination path is directed to the surface of the workpiece with minimal illumination deviation and distortion, and

wherein the first and second illumination paths are configured such that reflected illuminations from the first and second illumination paths in Mode-3 inspection maintaines a constant phase difference and interfere constructively.

15. The integrated system of claim 14 wherein:

a Mode-1 BF bandwidth of the Mode-1 BF illumination is about 380-700 nm;

a Mode-2 BF bandwidth of the Mode-2 BF illumination is about 380-700 nm; and

a Mode-3 IR bandwidth of the Mode-3 IR illumination is about 750-950 nm.

16. The integrated system of claim 14 or 15 wherein the reference mirror of the reference module comprises a dichroic mirror configured to allow Mode-1 and Mode-2 illuminations to pass therethrough to the reference illumination absorber wherein the Mode-1 and Mode 2

illuminations are absorbed and to reflect Mode-3 illumination, wherein the first and second illumination paths are configured such that reflected Mode-3 illuminations from the first and second illumination paths from the reference mirror and the surface of the workpiece in Mode-3 inspection maintains a constant phase difference and their distance from the primary beam splitter is configured to enable constructive interference.

17. The integrated system of any one of claims 13 to 16 wherein:

during Mode-1 inspection mode, only the Mode-1 illumination unit is activated while the Mode-2 and the Mode-3 illumination units are inactive;

during Mode-2 inspection mode, only the Mode-2 illumination unit is activated while the Mode-1 and the Mode-3 illumination units are inactive; and

during Mode-3 inspection mode, only the Mode-3 illumination unit is active while the Mode-1 and the Mode-2 illumination units are inactive.

18. The integrated system of any one of claims 13 to 17 wherein the beam splitter assembly module comprises:

a Mode-1/Mode-3 beam splitter, the Mode-1/Mode-3 beam splitter comprises a dichroic mirror configured to reflect Mode-3 illumination from the Mode-3 illumination unit and to transmit Mode-1 illumination from the Mode-1 illumination unit;

a Mode-2 beam splitter, the Mode-2 beam splitter is configured as a 50/50 Mode-2 beam splitter; and

a primary beam splitter configured as a 50/50 primary beam splitter.

19. The system of any one of claims 13 to 18 further comprises a telecentric lens, the telecentric lens provides a large field of view (FOV) and distortion-free imaging with minimal vignetting for inspecting the workpiece.

20. A method for inspection a surface of a workpiece, wherein the method distinguishes between types of submicron-sized irregularities on the surface of the workpiece, the method comprises:

performing a Mode-2 inspection mode by illuminating the surface of the workpiece with Mode-2 collimated BF illumination directed perpendicularly to the surface of the workpiece to obtain a Mode-2 image of the surface of the workpiece, wherein the Mode-2 image indicates possible micron-sized or greater and submicron-sized surface irregularities, wherein the surface irregularities include contaminates, cracks and grinding lines;

performing a Mode-3 inspection mode by illuminating the surface of the workpiece with Mode-3 collimated IR illumination to produce regular fringe patterns from the surface of the workpiece and to obtain a Mode-3 image of the fringe patterns;

analyzing Mode-2 and Mode-3 images, wherein analyzing includes

identifying an area in the Mode-2 image which indicates a possible surface irregularity,

analyzing the area in the Mode-3 image to determine if there is a fringe pattern change, and if the analysis indicates that

there are fringe pattern changes in the area, then infer that the surface irregularity is a crack, and

there are no fringe pattern changes in the area, then infer that the surface irregularity is not a crack.