

Claims

1. A method comprising:

providing an amount of illumination light to a semiconductor wafer at a plurality of defect locations in accordance with each of a plurality of optical modes at each of a plurality of focus planes within each of a plurality of vertically stacked structures disposed on the semiconductor wafer;

imaging an amount of light from each of the vertically stacked structures in response to the amount of illumination light in accordance with each of the plurality of optical modes at each of the plurality of focus planes at each of the plurality of defect locations;

selecting one or more defect locations from the plurality of defect locations;

generating a plurality of images at different focus planes through the vertically stacked structure at each of the selected defect locations in accordance with the plurality of optical modes;

selecting a subset of the plurality of focus planes, wherein the subset of the plurality of focus planes includes fewer focus planes than the plurality of focus planes; and

storing images at each of the plurality of defect locations at each of the selected subset of the plurality of focus planes in accordance with each of the plurality of optical modes.

2. The method of Claim 1, further comprising:

adjusting one or more parameter values of a defect detection algorithm associated with each of the plurality of optical modes to fit a wafer level signature measured at each of the plurality of optical modes to an expected wafer level signature;

selecting a subset of the plurality of optical modes for further consideration based on a goodness of the fit associated with each of the plurality of optical modes.

3. The method of Claim 1, further comprising:

estimating a signal to noise ratio associated with each of the plurality of optical modes;

and

selecting a subset of the plurality of optical modes for further consideration based on the estimated signal to noise ratio associated with each of the plurality of optical modes.

4. The method of Claim 1, further comprising:

performing a scanning electron microscopy (SEM) measurement at one or more of the selected defect locations without de-processing the semiconductor wafer; and

selecting a subset of the plurality of optical modes for further consideration based on the SEM measurements.

5. The method of Claim 1, further comprising:

verifying one or more defects buried within one or more of the plurality of vertically stacked structures disposed on the semiconductor wafer;

mapping each of the verified defects to corresponding images of defect locations at each of the selected subset of the plurality of focus planes in accordance with each of the plurality of optical modes; and

training a three dimensional nuisance filter to filter out nuisance defects based on the verified defects and the corresponding images.

6. The method of Claim 5, wherein the training is based on images of the verified defects and the corresponding images or feature vectors associated with the verified defects and feature vectors associated with the corresponding images.

7. The method of Claim 5, wherein the training involves training a machine learning network to filter out nuisance defects.

8. The method of Claim 5, wherein the training involves training a through focus feature based automatic classifier.

9. The method of Claim 5, wherein the training involves training a rule based tree classifier based on manually generated rules.

10. The method of Claim 5, further comprising:
filtering each of the images at each of the plurality of defect locations at each of the selected subset of the plurality of focus planes in accordance with each of the plurality of optical modes with the trained three dimensional nuisance filter;
and

selecting one optical mode from the plurality of optical modes based on a capture rate of real defects and a capture rate of nuisance defects associated with each of the plurality of optical modes.

11. The method of Claim 10, wherein the selecting involves adjusting one or more parameter values of a defect detection algorithm associated with each of the plurality of optical modes to achieve a predetermined nuisance capture rate selecting the optical mode that achieves the highest capture rate of real defects for the predetermined nuisance capture rate.

12. The method of Claim 5, wherein the verifying of the one or more buried defects involves a voltage contrast inspection of the semiconductor wafer.

13. The method of Claim 5, wherein the verifying of the one or more buried defects involves a bit-map test of the semiconductor wafer after complete fabrication of the semiconductor wafer.

14. The method of Claim 5, wherein the verifying of the one or more buried defects involves de-processing of the semiconductor wafer and review by a scanning electron microscope (SEM).

15. The method of Claim 5, wherein a location of each of the verified defects is stored in a KLA Results File (KLARF) file format.

16. The method of Claim 5, further comprising:
binning the images at each of the plurality of defect locations at each of the selected subset of the plurality of focus planes in accordance with each of the plurality of optical modes into a plurality of bins; and

selecting one or more of the plurality of defect locations from each of the plurality of bins to generate a diversity set of buried defects, wherein the one or more defects subject to verification includes the diversity set of buried defects.

17. A system comprising:

an illumination source that provides an amount of illumination light directed to a semiconductor wafer at a plurality of defect locations in accordance with each of a plurality of optical modes at each of a plurality of focus planes within each of a plurality of vertically stacked structures disposed on the semiconductor wafer;

a detector that generates a plurality of output signals indicative of an amount of light imaged from each of the vertically stacked structures in accordance with each of the plurality of optical modes at each of the plurality of focus planes at each of the plurality of defect locations; and

a computing system, including one or more processors and an amount of computer readable memory, configured to:

select one or more defect locations from the plurality of defect locations; generate a plurality of images at different focus planes through the vertically

stacked structure at each of the selected defect locations in accordance with the plurality of optical modes;

select a subset of the plurality of focus planes, wherein the subset of the plurality of focus planes includes fewer focus planes than the plurality of focus planes; and

store images at each of the plurality of defect locations at each of the selected subset of the plurality of focus planes in accordance with each of the plurality of optical modes.

18. The system of Claim 17, wherein the computing system is further configured to:

adjust one or more parameter values of a defect detection algorithm associated with each of the plurality of optical modes to fit a wafer level signature measured at each of the plurality of optical modes to an expected wafer level signature; and

select a subset of the plurality of optical modes for further consideration based on a goodness of the fit associated with each of the plurality of optical modes.

19. The system of Claim 17, wherein the computing system is further configured to:

estimate a signal to noise ratio associated with each of the plurality of optical modes; and select a subset of the plurality of optical modes for further consideration based on the estimated signal to noise ratio associated with each of the plurality of optical modes.

20. The system of Claim 17, further comprising:

a scanning electron microscopy (SEM) configured to perform a measurement at one or more of the selected defect locations without de-processing the semiconductor wafer, and wherein the computing system is further configured to select a subset of the plurality of optical modes for further consideration based on the SEM measurements.

21. The system of Claim 17, further comprising:

a defect verification system configured to verify one or more defects buried within one or more of the plurality of vertically stacked structures disposed on the semiconductor wafer, wherein the computing system is further configured to:

map each of the verified defects to corresponding images of defect locations at each of the selected subset of the plurality of focus planes in accordance with each of the plurality of optical modes; and

train a three dimensional nuisance filter to filter out nuisance defects based on the verified defects and the corresponding images.

22. A system comprising:

an illumination source that provides an amount of illumination light directed to a semiconductor wafer at a plurality of defect locations in accordance with each of a plurality of optical modes at each of a plurality of focus planes within each of a plurality of vertically stacked structures disposed on the semiconductor wafer;

a detector that generates a plurality of output signals indicative of an amount of light imaged from each of the vertically stacked structures in accordance with each of the plurality of optical modes at each of the plurality of focus planes at each of the plurality of defect locations; and

a computing system

comprising: one or

more processors;

and

a non-transitory, computer-readable medium storing instructions, that when executed by the one or more processors, cause the computing system to:

select one or more defect locations from the plurality of defect locations; generate a plurality of images at different focus planes through the

vertically stacked structure at each of the selected defect locations in accordance with the plurality of optical modes;

select a subset of the plurality of focus planes, wherein the subset of the plurality of focus planes includes fewer focus planes than the plurality of focus planes; and

store images at each of the plurality of defect locations at each of the selected subset of the plurality of focus planes in accordance with each of the plurality of optical modes.

23. The system of Claim 22, the non-transitory, computer-readable medium further storing instructions, that when executed by the one or more processors, cause the computing system to:

adjust one or more parameter values of a defect detection algorithm associated with each of the plurality of optical modes to fit a wafer level signature measured at each of the plurality of optical modes to an expected wafer level signature; and

select a subset of the plurality of optical modes for further consideration based on a goodness of the fit associated with each of the plurality of optical modes.

24. The system of Claim 22, the non-transitory, computer-readable medium further storing instructions, that when executed by the one or more processors, cause the computing system to:

estimate a signal to noise ratio associated with each of the plurality of optical modes; and select a subset of the plurality of optical modes for further consideration based on the estimated signal to noise ratio associated with each of the plurality of optical modes.

25. The system of Claim 22, further comprising:

a scanning electron microscopy (SEM) configured to perform a measurement at one or more of the selected defect locations without de-processing the semiconductor wafer, the non-transitory, computer-readable medium further storing instructions, that when executed by the one or more processors, cause the computing system to select a subset of the plurality of optical modes for further consideration based on the SEM measurements.

26. The system of Claim 22, further comprising:

a defect verification system configured to verify one or more defects buried within one or more of the plurality of vertically stacked structures disposed on the semiconductor wafer, the non-transitory, computer-readable medium further storing instructions, that when executed by

the one or more processors, cause the computing system to:

map each of the verified defects to corresponding images of defect locations at each of the selected subset of the plurality of focus planes in accordance with each of the plurality of optical modes; and

train a three dimensional nuisance filter to filter out nuisance defects based on the verified defects and the corresponding images.