

Claims

1. A system configured to detect defects on a reticle, comprising:
 - an inspection subsystem configured to scan a wafer to thereby generate images for the wafer, wherein a reticle is used to print features on the wafer in a lithography process; and
 - one or more computer subsystems comprising:
 - one or more image processing components configured for acquiring the images generated by the inspection subsystem for the wafer;
 - a main user interface component configured for providing information generated for the wafer and the reticle to a user and for receiving instructions from the user; and
 - an interface component configured for providing an interface between t one or more image processing components and the main user interface component and for controlling one or more hardware elements of the inspection subsystem;
 - wherein the one or more image processing components are further configured for performing repeater defect detection by applying a repeater defect detection algorithm to the images acquired by the one or more image processing components, and wherein the repeater defect detection algorithm is configured to detect defects on the wafer using a hot threshold and to identify the defects that are repeater defects;

wherein the one or more image processing components are further configured for sending inspection results comprising information for only the repeater defects to the interface component; and

wherein the one or more computer subsystems are configured for identifying defects on the reticle based on the repeater defects detected on the wafer.

2. The system of claim 1, wherein the repeater defect detection algorithm is further configured to identify the defects that are the repeater defects by comparing the within die defect coordinates for different of the defects to each other.
3. The system of claim 1, wherein the one or more image processing components are further configured for storing information for all of the detected defects.
4. The system of claim 1, wherein performing the repeater defect detection is performed for only a single swath on the wafer.
5. The system of claim 1, wherein the one or more image processing components are further configured as a virtual inspector, and wherein the one or more computer subsystems are further configured for disconnecting the virtual inspector from the inspection subsystem after the images are acquired from the inspection subsystem and before the repeater defect detection is performed.
6. The system of claim 1, wherein the one or more image processing components are further configured for performing single swath-multiple die row defect detection by applying a defect detection algorithm to the images generated by the inspection subsystem for the same single swath in multiple die rows on the wafer and for sending results of the single swath-multiple die row defect detection to the interface component, and wherein

the interface component or the main user interface component performs repeater defect detection on the results of the single swath-multiple die defect detection.

7. The system of claim 1, wherein the one or more image processing components comprise a shared non-transitory computer-readable storage medium accessible for multiple processes performed by the one or more image processing components, and wherein the repeater defect detection algorithm is further configured to detect the defects on the entire inspected area of the wafer, to store all of the detected defects in the shared non-transitory computer-readable storage medium, and to identify the defects that are the repeater defects using all of the stored detected defects for the entire inspected area of the wafer.

8. The system of claim 1, wherein the one or more image processing components are further configured for performing single swath-multiple die row defect detection by applying a defect detection algorithm to the images generated by the inspection subsystem for the same single swath in multiple die rows on the wafer and storing results of the single swath-multiple die row defect detection in a shared non-transitory computer-readable storage medium in the one or more image processing components accessible for multiple processes performed by the one or more image processing components, and wherein the repeater defect detection algorithm is further configured to detect the defects in the entire inspected area of the same single swath in the multiple die rows, to store all of the detected defects in the shared non-transitory computer-readable storage medium, and to identify the defects that are the repeater defects using all of the stored detected defects for the entire inspected area of the same single swath in the multiple die rows.

9. The system of claim 1, wherein the one or more image processing components comprise a shared non-transitory computer-readable storage medium accessible for multiple processes performed by the one or more image processing components, wherein the one or more computer subsystems further comprise a virtual inspector, wherein the one or more image processing components are further configured for storing only a first

portion of results produced by the repeater defect detection algorithm in the shared non-transitory computer-readable storage medium and only a second portion of the results produced by the repeater defect detection algorithm in the virtual inspector, wherein the first portion comprises only defect coordinates for the defects detected on the wafer, wherein the second portion comprises only defect attributes and patch images for the detected defects on the wafer, wherein the repeater defect detection algorithm is further configured to identify the repeater defects using only the first portion of the results, and wherein the one or more image processing components are further configured for retrieving the defect attributes and patch images for the repeater defects from the virtual inspector and generating the inspection results by combining information generated by identifying the repeater defects with the retrieved defect attributes and patch images.

10. The system of claim 1, wherein the one or more image processing components comprise a shared non-transitory computer-readable storage medium accessible for multiple processes performed by the one or more image processing components, wherein the one or more image processing components are further configured for storing only a first portion of results produced by the repeater defect detection algorithm in the shared non-transitory computer-readable storage medium, wherein the first portion comprises only defect coordinates for the defects detected on the wafer, wherein the repeater defect detection algorithm is further configured to identify the repeater defects using only the first portion of the results, wherein the interface component is further configured for controlling the one or more hardware elements of the inspection subsystem to thereby scan only locations on the wafer of the identified repeater defects, and wherein the one or more image processing components are further configured for combining images generated in the scan of only the locations on the wafer of the identified repeater defects with the first portion of the results to thereby generate the inspection results that are sent to the interface component.

11. The system of claim 1, wherein the repeater defect detection algorithm is further configured to identify the defects that appear at the same location in two or more printed instances of the reticle on the wafer as the repeater defects.

12. The system of claim 1, wherein the one or more computer subsystems are further configured for identifying the defects on the reticle by determining which of the repeater defects repeat in two or more printed instances of the reticle on the wafer and identifying the repeater defects that repeat in the two or more printed instances of the reticle on the wafer as the defects on the reticle.

13. The system of claim 1, wherein identifying the defects on the reticle is performed by the main user interface component included in the one or more computer subsystems.

14. The system of claim 1, wherein the repeater defect detection algorithm is further configured to detect the defects by generating three or more difference images for each test frame of the images generated for the wafer by subtracting three or more reference frames from the test frame, respectively, applying at least one threshold to the three or more difference images, and determining that a defect is present in the test frame when results of two or more of said applying the at least one threshold to the three or more difference images indicate that a defect is present.

15. The system of claim 1, wherein the repeater defect detection algorithm is further configured to detect the defects by comparing each test frame of the images generated for the wafer to an average of multiple reference frames.

16. The system of claim 1, wherein the repeater defect detection algorithm is further configured to detect the defects by generating a mean of multiple frames of the images generated for the wafer corresponding to the same location within each reticle instance printed on the wafer and subtracting the mean from reference frames from dies on the wafer at different locations within multiple reticle instances printed on the wafer.

17. The system of claim 1, wherein the repeater defect detection algorithm is further configured to detect the defects by generating a mean of multiple frames of the images generated for the wafer corresponding to the same location within each reticle instance printed on the wafer and subtracting the mean from a mean of reference frames from other dies at different locations within multiple reticle instances printed on the wafer.

18. The system of claim 1, wherein the repeater defect detection algorithm is further configured to identify the defects that are the repeater defects by adding image frames corresponding to a location of a detected defect in multiple instances of the reticle printed on the wafer, comparing the added image frames to a threshold, and determining that the defect is a repeater defect when the added image frames are above the threshold.

19. The system of claim 1, wherein the repeater defect detection algorithm is further configured a) to detect the defects and to identify the defects that are the repeater defects in only a first swath by identifying the defects that appear at the same location in a first number of instances of the reticle printed on the wafer as the repeater defects and b) to subsequently detect the defects and to identify the defects that are the repeater defects in other swaths by identifying the defects that appear at the same location in a second number of instances of the reticle printed on the wafer as the repeater defects, and wherein the second number is higher than the first number.

20. The system of claim 19, wherein the repeater defect detection algorithm is further configured to reduce noise in the first swath by filtering out systematic noise that occurs in every instance of the reticle printed on the wafer in the first swath and at the same location in each die instance of the reticle printed on the wafer in the first swath.

21. The system of claim 1, wherein the repeater defect detection algorithm is further configured to detect the defects by comparing image frames of reticle instances printed on the wafer to a standard image frame generated from a different wafer.

22. The system of claim 1, wherein the repeater defect detection algorithm is further configured to detect the defects by comparing image frames of reticle instances printed on the wafer to a median image frame generated from a different wafer.

23. The system of claim 1, wherein the repeater defect detection algorithm is further configured to detect the defects by comparing image frames of reticle instances printed on the wafer to a rendered design.

24. The system of claim 1, wherein the hot threshold comprises a local multiple die adaptive threshold.

25. The system of claim 1, wherein the one or more image processing components are further configured for storing information for the detected defects in shared memory per node of the one or more image processing components.

26. The system of claim 25, wherein the information stored for the detected defects in the shared memory comprises information for only defects detected in one or more first die rows on the wafer.

27. The system of claim 26, wherein the repeater defect detection algorithm is further configured to identify the defects that are the repeater defects by identifying defects detected in adjacent dies in the one or more first die rows at the same die relative locations as the repeater defects and identifying defects not detected in the adjacent dies in the one or more first die rows at the same die relative locations as non-repeater defects.

28. The system of claim 27, wherein the repeater defect detection algorithm is further configured to identify the defects that are the repeater defects by identifying defects detected in adjacent dies in other die rows on the wafer at the same die relative locations

as the repeater defects and identifying defects not detected in the adjacent dies in the other die rows at the same die relative locations as non-repeater defects.

29. The system of claim 28, wherein the repeater defect detection algorithm is further configured to identify the defects that are the repeater defects by extracting portions of the images generated for the wafer at the same die relative locations as the non-repeater defects and applying a local defect detection algorithm to the extracted portions of the images to thereby determine if undetected defects repeat at the same die relative locations as the non-repeater defects.

30. The system of claim 1, wherein the repeater defect detection algorithm is further configured to align the images generated for the wafer to a design for the wafer with sub-pixel accuracy.

31. The system of claim 1, wherein the repeater defect detection algorithm is further configured to determine which of the repeater defects are defects of interest and which of the repeater defects are nuisances using a machine learning technique performed based on attributes of the repeater defects, properties of the images corresponding to the repeater defects, or a combination thereof

32. The system of claim 1, wherein the repeater defect detection algorithm is further configured to align the images generated for the wafer to each other by identifying a common alignment target in two portions of the images processed by the repeater defect detection algorithm as two different jobs, respectively, aligning the two different jobs to each other using the common alignment target, determining an alignment offset based on results of said aligning, and applying the alignment offset to other jobs to thereby align the other jobs to the two different jobs.

33. The system of claim 32, wherein the two different jobs are located in different die rows on the wafer.

34. A non-transitory computer-readable medium, storing program instructions executed on one or more computer subsystems for performing a computer-implemented method for detecting defects on a reticle, wherein the computer-implemented method comprises:

acquiring images generated for a wafer by an inspection subsystem, wherein a reticle is used to print features on the wafer in a lithography process, and wherein said acquiring is performed by one or more image processing components included in the one or more computer subsystems;

wherein the one or more computer subsystems comprise a main user interface configured for providing information generated for the wafer and the reticle to a user and for receiving instructions from the user; and

wherein the one or more computer subsystems further comprise an interface component configured for providing an interface between the one or more image processing components and the main user interface component and for controlling one or more hardware elements of the inspection subsystem;

performing repeater defect detection by applying a repeater defect detection algorithm to the images acquired by the one or more image processing components, wherein the repeater defect detection algorithm is configured to detect defects on the wafer using a hot threshold and to identify the defects that are repeater defects, and wherein the repeater defect detection is performed by the one or more image processing components;

sending inspection results comprising information for only the repeater defects from the one or more image processing components to the interface component; and

identifying defects on the reticle based on the repeater defects detected on the wafer, wherein identifying the defects on the reticle is performed by the one or more computer subsystems.

35. A computer-implemented method for detecting defects on a reticle, comprising:

acquiring images generated for a wafer by an inspection subsystem, wherein a reticle is used to print features on the wafer in a lithography process, and wherein said acquiring is performed by one or more image processing components included in one or more computer subsystems;

wherein the one or more computer subsystems comprise a main user interface configured for providing information generated for the wafer and the reticle to a user and for receiving instructions from the user; and

wherein the one or more computer subsystems further comprise an interface component configured for providing an interface between the one or more image processing components and the main user interface component and for controlling one or more hardware elements of the inspection subsystem;

performing repeater defect detection by applying a repeater defect detection algorithm to the images acquired by the one or more image processing components, wherein the repeater defect detection algorithm is configured to detect defects on the wafer using a hot threshold and to identify the

defects that are repeater defects, and wherein the repeater defect detection is performed by the one or more image processing components;

sending inspection results comprising information for only the repeater defects from the one or more image processing components to the interface component; and

identifying defects on the reticle based on the repeater defects detected on the wafer, wherein identifying the defects on the reticle is performed by the one or more computer subsystems.