CLAIMS

What is claimed is:

1. A method of classifying a defect on a substrate surface, the method comprising:

scanning a primary electron beam over a target region of the substrate surface causing secondary electrons to be emitted therefrom, wherein the target region includes the defect;

detection of the secondary electrons from the target region using a plurality of at least two off-axis sensors so as to generate a plurality of image frames of the target region, each image frame of the target region including data from a different off-axis sensor;

processing the plurality of image data frames to generate a surface height map of the target region;

determining surface height attributes for the defect based on the surface height map of the target region; and

feeding the surface height attributes for the defect into a defect classifier.

2. The method of claim 1, wherein the surface height attributes include a difference in height between a defect area and a background area surrounding the defect area.

3. The method of claim 2, wherein the surface height attributes further include a measure of height variation within the defect area.

4. The method of claim 3, wherein the surface height attributes further include a measure of height variation within the background area surrounding the defect area.

5. The method of claim 4, wherein the substrate surface comprises a bare semiconductor surface.

6. The method of claim 4, wherein the substrate surface comprises a patterned surface.

7. The method of claim 6, further comprising:

detection of the secondary electrons from a reference site using the plurality of at least two off-axis sensors so as to generate a plurality of image frames of the reference site, each image frame of the reference site including data from a different off-axis sensor; and

aligning the image frames of the target region with the image frames of the reference site.

8. The method of claim 7, further comprising:

processing the plurality of image frames of the reference site to generate a surface height map of the reference site.

9. The method of claim 8, wherein determining the surface height attributes for the defect is also based on the surface height map of the reference site.

10. The method of claim 9, wherein the surface height attributes further includes a difference in height between the defect area and a corresponding non-defective area in the reference site.

11. An apparatus comprising:

a source for generating a primary electron beam;

scan deflectors configured to controllably deflect the primary electron beam;

a control system configured to control the scan deflectors such that the primary electron beam is scanned over a target region such that secondary electrons are emitted therefrom, wherein the target region includes a defect;

a detection system configured for the detection of the secondary electrons using a plurality of at least two off-axis sensors so as to generate a plurality of image frames of the target region, each image frame including data from a different off-axis sensor; and

an image data processing system configured to process the plurality of image frames to generate a surface height map of the target region, determine surface height attributes for the defect using the surface height map of the target region, and input the surface height attributes for the defect into a defect classifier.

12. The apparatus of claim 11, wherein the surface height attributes include a difference in height between a defect area and a background area surrounding the defect area.

13. The apparatus of claim 12, wherein the surface height attributes further include a measure of height variation within the defect area.

14. The apparatus of claim 13, wherein the surface height attributes further include a measure of height variation within the background area surrounding the defect area.

15. The apparatus of claim 11, wherein the off-axis sensors comprise off-axis detector segments.

16. The apparatus of claim 11, wherein the control system is further configured to control the scan deflectors such that the primary electron beam is scanned over a reference site so that a plurality of image frames of the reference site is generated by the detection system.

17. The apparatus of claim 16, wherein the image data processing system is further configured to align the image frames of the target region with the image frames of the reference site.

18. The apparatus of claim 17, wherein the image data processing system is further configured to process the plurality of image frames of the reference site so as to generate a surface height map of the reference site.

19. The apparatus of claim 18, wherein the image processing system if further configured to also use the surface height map of the reference site in determining the surface height attributes of the defect.

20. The apparatus of claim 19, wherein the surface height attributes comprise:

a difference in height between a defect area and a background area surrounding the defect area;

a measure of height variation within the defect area;

a measure of height variation within the background area surrounding the defect area; and

a difference in height between the defect area and a corresponding non-defective area in the reference site.

CLAIMS

1. A method of classifying a defect on a substrate surface, the method comprising:

scanning a primary electron beam over a target region of the substrate surface causing secondary electrons to be emitted therefrom, wherein the target region includes the defect;

detection of the secondary electrons from the target region using a plurality of at least two off-axis sensors so as to generate a plurality of image frames of the target region, each image frame of the target region including data from a different off-axis sensor;

processing the plurality of image data frames to generate a surface height map of the target region;

determining surface height attributes for the defect based on the surface height map of the target region, wherein the surface height attributes include a difference in height between an average height of a defect area and an average height of a background area surrounding the defect area; and

feeding the surface height attributes for the defect into a defect classifier.

2. The method of claim **1**, wherein the surface height attributes further include a statistical measure of height variation within the defect area.

3. The method of claim **2**, wherein the surface height attributes further include a statistical measure of height variation within the background area surrounding the defect area.

4. The method of claim **3**, wherein the substrate surface comprises a bare semiconductor surface.

5. The method of claim 3, wherein the substrate surface comprises a patterned surface.

6. The method of claim 5, further comprising:

detection of the secondary electrons from a reference site using the plurality of at least two off-axis sensors so as to generate a plurality of image frames of the reference site, each image frame of the reference site including data from a different off-axis sensor; and

aligning the image frames of the target region with the image frames of the reference site.

7. The method of claim 6, further comprising:

processing the plurality of image frames of the reference site to generate a surface height map of the reference site.

8. The method of claim 7, wherein determining the surface height attributes for the defect is also based on the surface height map of the reference site.

9. The method of claim 8, wherein the surface height attributes further includes a difference in height between the defect area relative to the background area surrounding the defect area and a corresponding non-defective area in the reference site relative to a background area surrounding the corresponding non-defective area.

10. An apparatus comprising:

a source for generating a primary electron beam;

scan deflectors configured to controllably deflect the primary electron beam;

a control system configured to control the scan deflectors such that the primary electron beam is scanned over a target region such that secondary electrons are emitted therefrom, wherein the target region includes a defect;

a detection system configured for the detection of the secondary electrons using a plurality of at least two off-axis

sensors so as to generate a plurality of image frames of the target region, each image frame including data from a different off-axis sensor; and

an image data processing system configured to process the plurality of image frames to generate a surface height map of the target region, determine surface height attributes for the defect using the surface height map of the target region, and input the surface height attributes for the defect into a defect classifier, wherein the surface height attributes include a difference in height between an average height of a defect area and an average height of a background area surrounding the defect area.

11. The apparatus of claim **10**, wherein the surface height attributes further include a statistical measure of height variation within the defect area.

12. The apparatus of claim **11**, wherein the surface height attributes further include a statistical measure of height variation within the background area surrounding the defect area.

13. The apparatus of claim **10**, wherein the off-axis sensors comprise off-axis detector segments.

14. The apparatus of claim **10**, wherein the control system is further configured to control the scan deflectors such that the primary electron beam is scanned over a reference site so that a plurality of image frames of the reference site is generated by the detection system.

15. The apparatus of claim **14**, wherein the image data processing system is further configured to align the image frames of the target region with the image frames of the reference site.

16. The apparatus of claim **15**, wherein the image data processing system is further configured to process the plurality of image frames of the reference site so as to generate a surface height map of the reference site.

17. The apparatus of claim **16**, wherein the image processing system if further configured to also use the surface height map of the reference site in determining the surface height attributes of the defect.

18. The apparatus of claim **17**, wherein the surface height attributes comprise:

a statistical measure of height variation within the defect area;

a statistical measure of height variation within the background area surrounding the defect area; and

a difference in height between the defect area and a corresponding non-defective area in the reference site.

19. The method of claim **2**, wherein the statistical measure comprises a standard deviation.

20. The apparatus of claim **11**, wherein the statistical measure comprises a standard deviation.