Claims:

1. A method for training a machine learning (ML) model for automatic defect detection and classification of at least a portion of a processed wafer, comprising:

receiving labeled images having multiple defect classification types and respective features for at least a portion of a post-processed wafer;

creating a first training set comprising the received labeled images having the multiple defect classification types and respective features for the portions of the wafer;

training the machine learning model in a first stage to automatically classify wafer portions based on at least one detected defect in a respective wafer portion using the first training set;

receiving labeled wafer profiles having respective downstream yield data;

creating a second training set comprising the labeled wafer profiles having the respective downstream yield data; and

training the machine learning model, using the second training set, to automatically determine a respective downstream yield of a wafer based on a respective wafer profile.

2. The method of claim 1, wherein the multiple defect classification types comprise at least one of a good category, a void category, or a delamination category.

3. The method of claim 1, wherein the ML model comprises at least one of a convolutional neural network model or a recurrent neural network model.

4. A method for automatic defect detection and classification of at least a portion of a processed wafer using a trained machine learning (ML) model, comprising:

receiving at least one unlabeled image of at least a portion of a processed wafer;

processing the at least a portion of the processed wafer to separate image pixels depicting image objects from image pixels depicting image background;

determining features for the image pixels depicting image objects;

applying the trained ML model to the features determined for the image pixels depicting image objects, the machine learning model having been trained using a first set of labeled images including features associated with and identifying respective wafer defect classification types; and

determining a defect classification for at least one portion of the at least one unlabeled wafer image using the trained machine learning model; and

determining a downstream yield of at least one wafer depicted in the unlabeled image using the trained machine learning model, the machine learning model having been further trained using a second set of labeled wafer profiles having respective downstream yield data for imaged wafers to train the machine learning model to automatically determine a respective downstream yield of a wafer based on a determined, respective wafer profile.

5. The method of claim 4, further comprising determining a wafer profile for at least one wafer depicted in the unlabeled wafer image by compiling determined defect classification types for at least some of the portions of the at least one portion of the at least one unlabeled wafer image.

6. The method of claim 4, wherein the downstream yield of a wafer is determined based on a compilation of an electrical conductivity of each of the pixels of the at least the portion of the wafer.

7. The method of claim 5, further comprising:

determining if a wafer contains a critical defect from the at least one determined wafer profile.

8. The method of claim 4, wherein the wafer defect classification types comprise at least one of a good category, a void category, or a delamination category.

9. The method of claim 4, wherein the trained ML model comprises at least one of a convolutional neural network model or a recurrent neural network model.

10. An apparatus for training a machine learning (ML) model for automatic defect detection and classification of at least a portion of a processed wafer, comprising:

a processor; and

a memory having stored therein at least one program, the at least one program including instructions which, when executed by the processor, cause the apparatus to perform a method, comprising;

receiving labeled images having multiple defect classification types and respective features for at least a portion of a post-processed wafer;

creating a first training set comprising the received labeled images having the multiple defect classification types and respective features for the portions of the wafer;

training the machine learning model in a first stage to automatically classify wafer portions based on at least one detected defect in a respective wafer portion using the first training set;

receiving labeled wafer profiles having respective downstream yield data;

creating a second training set comprising the labeled wafer profiles having the respective downstream yield data; and

training the machine learning model, using the second training set, to automatically determine a respective downstream yield of a wafer based on a respective wafer profile.

11. The apparatus of claim 10, wherein the multiple defect classification types comprise at least one of a good category, a void category, or a delamination category.

12. The apparatus of claim 10, wherein the ML model comprises at least one of a convolutional neural network model or a recurrent neural network model.

13. An apparatus for automatic defect detection and classification of at least a portion of a processed wafer using a trained machine learning (ML) model, comprising:

a processor; and

a memory having stored therein at least one program, the at least one program including instructions which, when executed by the processor, cause the apparatus to perform a method, comprising;

receiving at least one unlabeled image of at least a portion of a processed wafer;

processing the at least a portion of the processed wafer to separate image pixels depicting image objects from image pixels depicting image background;

determining features for the image pixels depicting image objects;

applying the trained ML model to the features determined for the image pixels depicting image objects, the machine learning model having been trained using a first set of labeled images including features associated with and identifying respective wafer defect classification types; and

determining a defect classification for at least one portion of the at least one unlabeled wafer image using the trained machine learning model; and

determining a downstream yield of at least one wafer depicted in the unlabeled image using the trained machine learning model, the machine learning model having been further trained using a second set of labeled wafer profiles having respective downstream yield data for imaged wafers to train the machine learning model to automatically determine a respective downstream yield of a wafer based on a determined, respective wafer profile.

14. The apparatus of claim 13, further comprising determining a wafer profile for at least one wafer depicted in the unlabeled wafer image by compiling determined defect classification types for at least some of the portions of the at least one portion of the at least one unlabeled wafer image.

15. The apparatus of claim 13, wherein a downstream yield of a wafer is determined based on a compilation of an electrical conductivity of each of the pixels of the at least the portion of the wafer.

16. The apparatus of claim 14, further comprising:

determining if a wafer contains a critical defect from the at least one determined wafer profile.

17. The apparatus of claim 13, wherein the wafer defect classification types comprise at least one of a good category, a void category, or a delamination category.

18. The apparatus of claim 13, wherein the trained ML model comprises at least one of a convolutional neural network model or a recurrent neural network model.