Claims

1. A process control system, comprising: a controller configured to communicatively couple to a lithography tool fabricating a current layer to provide control parameters to maintain overlay error between the current layer and one or more previous layers within a selected specification, the controller including one or more processors configured to execute program instructions configured to cause the one or more processors to: receive after-development inspection (ADI) data after a lithography step for the current layer from an ADI tool, the ADI data including ADI overlay data indicative of overlay errors between the current layer and the one or more previous layers, the ADI data further including ADI flag data indicative of process deviations during fabrication of the one or more previous layers; receive after etch inspection (AEI) overlay data after an exposure step of the current layer from an AEI tool, the AEI overlay data indicative of overlay errors between the current layer and the one or more previous layers, wherein a non-zero offset corresponds to a difference between overlay error determined from ADI data and AEI overlay data; train a non-zero offset predictor with ADI data and AEI overlay data from one or more training samples to predict a non-zero offset from ADI data; generate values of the control parameters of the lithography tool fabricating the current layer of at least one production sample using ADI data from one or more previous production samples and non-zero offsets generated by the non-zero offset predictor based on the ADI data from the one or more previous production samples; and provide the values of the control parameters to the lithography tool for fabricating the current layer on the at least one production sample.

2. The process control system of claim 1, wherein the one or more processors are further configured to execute program instructions configured to cause the one or more processors to: receive ADI flag data from one or more subsequent layers on at least one production sample in a previous lot, the one or more subsequent layers fabricated above the current layer in the previous lot; and train the non-zero offset predictor with the ADI flag data from the one or more subsequent layers.

3. The process control system of claim 2, wherein generating the values of the control parameters of the lithography tool further comprises: generating the values of the control parameters of the lithography tool based at least in part on non-zero offsets generated by the non-zero offset predictor based on the ADI flag data from the one or more subsequent layers on the at least one production sample in the previous lot.

4. The process control system of claim 1, wherein the ADI flag data of a metrology target is generated by analyzing one or more regions of interest of the metrology target based on a target metric.

5. The process control system of claim 4, wherein the metrology target includes a periodic structure, wherein the target metric comprises: decomposing at least one of the one or more regions into a periodic component, a linear component, and a noise component.

6. The process control system of claim 5, wherein the target metric further comprises: at least one of a strength of the periodic component, a ratio of the strength of the periodic component to a strength of the noise component.

7. The process control system of claim 4, wherein the metrology target includes a periodic structure, wherein the target metric comprises: a measure of the symmetry of the one or more regions of interest.

8. The process control system of claim 1, wherein the ADI metrology tool has a higher throughput than the AEI metrology tool.

9. The process control system of claim 1, wherein the AEI metrology tool has a higher resolution than the ADI metrology tool.

10. The process control system of claim 1, wherein the ADI overlay data and the ADI flag data are generated using a composite metrology recipe.

11. The process control system of claim 10, wherein the composite recipe includes a first set of sampling locations for measuring the ADI overlay data and a second set of sampling locations for measuring the ADI flag data.

12. The process control system of claim 11, wherein the first set of sampling locations is larger than the second set of sampling locations.

13. The process control system of claim 1, wherein the ADI overlay data and the ADI flag data are generated on different metrology targets.

14. The process control system of claim 1, wherein the ADI overlay data and the ADI flag data are generated on different cells of common metrology targets.

15. The process control system of claim 1, wherein the ADI tool comprises: an optical metrology tool.

16. The process control system of claim 1, wherein the AEI tool comprises: a particle-beam metrology tool.

17. The process control system of claim 16, wherein the particle-beam metrology tool comprises: at least one of an electron beam metrology tool or an ion-beam metrology tool.

18. A process control system, comprising: a controller configured to communicatively couple to a lithography tool fabricating a current layer to provide control parameters to maintain overlay error between the current layer and one or more previous layers within a selected specification, the controller including one or more processors configured to execute program instructions configured to cause the one or more processors to: receive after-development inspection (ADI) data after a lithography step for the current layer from an ADI tool, the ADI data including ADI overlay data indicative of overlay errors between the current layer and the one or more previous layers, the ADI data further including ADI flag data indicative of process deviations during fabrication of the one or more previous layers; receive after etch inspection (AEI) overlay data after an exposure step of the current layer from an AEI tool, the AEI overlay data indicative of overlay errors between the current layer and the one or more previous layers, wherein a non-zero offset corresponds to a difference between overlay error determined from ADI data and AEI overlay data; generate values of the control parameters

of the lithography tool fabricating the current layer of at least one production sample using ADI data and AEI data from one or more previous production samples; and provide the values of the control parameters to the lithography tool for fabricating the current layer on the at least one production sample.

19. The process control system of claim 18, wherein generating the values of the control parameters of the lithography tool fabricating the current layer of the at least one production sample using ADI data and AEI data from the one or more previous production samples comprises: training a non-zero offset predictor with ADI data and AEI overlay data from one or more training samples to predict a non-zero offset from ADI data; and generating the values of the control parameters based on ADI data from the one or more previous production samples and non-zero offsets generated by the non-zero offset predictor based on the ADI data from the one or more previous production samples.

20. The process control system of claim 18, wherein generating the values of the control parameters of the lithography tool fabricating the current layer of the at least one production sample using ADI data and AEI overlay data from the one or more previous production samples comprises: updating the values of the control parameters based on the ADI data with a first frequency; and updating the values of the control parameters based on the AEI overlay data with a second frequency lower than the first frequency.

21. The process control system of claim 18, wherein the one or more processors are further configured to execute program instructions configured to cause the one or more processors to: receive ADI flag data from one or more subsequent layers on at least one production sample in a previous lot, the one or more subsequent layers fabricated above the current layer in the previous lot.

22. The process control system of claim 21, wherein generating the values of the control parameters of the lithography tool further comprises: generating the values of the control parameters of the lithography tool based at least in part on the ADI flag data from the one or more subsequent layers on the at least one production sample in the previous lot.

23. The process control system of claim 18, wherein the ADI flag data of a metrology target is generated by analyzing one or more regions of interest of the metrology target based on a target metric.

24. The process control system of claim 23, wherein the metrology target includes a periodic structure, wherein the target metric comprises: decomposing at least one of the one or more regions into a periodic component, a linear component, and a noise component.

25. The process control system of claim 24, wherein the target metric further comprises: at least one of a strength of the periodic component, a ratio of the strength of the periodic component to a strength of the noise component.

26. The process control system of claim 23, wherein the metrology target includes a periodic structure, wherein the target metric comprises: a measure of the symmetry of the one or more regions of interest.

27. The process control system of claim 18, wherein the ADI metrology tool has a higher throughput than the AEI metrology tool.

28. The process control system of claim 18, wherein the AEI metrology tool has a higher resolution than the ADI metrology tool.

29. The process control system of claim 18, wherein the ADI overlay data and the ADI flag data are generated using a composite metrology recipe.

30. The process control system of claim 29, wherein the composite recipe includes a first set of sampling locations for measuring the ADI overlay data and a second set of sampling locations for measuring the ADI flag data.

31. The process control system of claim 30, wherein the first set of sampling locations is larger than the second set of sampling locations.

32. The process control system of claim 18, wherein the ADI overlay data and the ADI flag data are generated on different metrology targets.

33. The process control system of claim 18, wherein the ADI overlay data and the ADI flag data are generated on different cells of common metrology targets.

34. The process control system of claim 18, wherein the ADI tool comprises: an optical metrology tool.

35. The process control system of claim 18, wherein the AEI tool comprises: a particle-beam metrology tool.

36. The process control system of claim 35, wherein the particle-beam metrology tool comprises: at least one of an electron beam metrology tool or an ion-beam metrology tool.

37. A process control system, comprising: an after-development inspection (ADI) tool; an after-etch inspection (AEI) tool; a lithography tool for fabricating a current layer; and a controller configured to communicatively couple to the ADI tool, the AEI tool, and the lithography tool to provide control parameters to maintain overlay error between the current layer and one or more previous layers within a selected specification, the controller including one or more processors configured to execute program instructions configured to cause the one or more processors to: receive after-development inspection (ADI) data after a lithography step for the current layer from the ADI tool, the ADI data including ADI overlay data indicative of overlay errors between the current layer and the one or more previous layers, the ADI data further including ADI flag data indicative of process deviations during fabrication of the one or more previous layers; receive after etch inspection (AEI) overlay data after an exposure step of the current layer from the AEI tool, the AEI overlay data indicative of overlay errors between the current layer and the one or more previous layers, wherein a non-zero offset corresponds to a difference between overlay error determined from ADI data and AEI overlay data; train a non-zero offset predictor with ADI data and AEI overlay data from one or more training samples to predict a non-zero offset from ADI data; generate values of the control parameters of the lithography tool fabricating the current layer

of at least one production sample using ADI data from one or more previous production samples and non-zero offsets generated by the non-zero offset predictor based on the ADI data from the one or more previous production samples; and provide the values of the control parameters to the lithography tool for fabricating the current layer on the at least one production sample.

38. A non-zero offset predictor, comprising: a controller including one or more processors configured to execute program instructions configured to cause the one or more processors to: receive training data, the training data including: after-development inspection (ADI) data after a lithography step for a current layer from an ADI tool, the ADI data including ADI overlay data indicative of overlay errors between the current layer and one or more previous layers, the ADI data further including ADI flag data indicative of process deviations during fabrication of the one or more previous layers; after etch inspection (AEI) overlay data after an exposure step of the current layer from an AEI tool, the AEI overlay data indicative of overlay errors between the current layer and the one or more previous layers, wherein a non-zero offset corresponds to a difference between overlay error determined from ADI data and AEI overlay data; predict values of the non-zero offset using ADI data from one or more previous production samples and the training data; provide the non-zero offset to a process controller for adjusting values of control parameters of a lithography tool for fabricating the current layer on at least one production sample.

39. A process control method, comprising: receiving after-development inspection (ADI) data after a lithography step for a current layer from an ADI tool, the ADI data including ADI overlay data indicative of overlay errors between the current layer and one or more previous layers, the ADI data further including ADI flag data indicative of process deviations during fabrication of the one or more previous layers; receiving after etch inspection (AEI) overlay data after an exposure step of the current layer from an AEI tool, the AEI overlay data indicative of overlay errors between the current layer and the one or more previous layers, wherein a non-zero offset corresponds to a difference between overlay error determined from ADI data and AEI overlay data; training a non-zero offset predictor with ADI data and AEI overlay data from one or more training samples to predict a non-zero offset from ADI data; generating values of control parameters of a lithography tool for fabricating the current layer of at least one production sample using ADI data from one or more previous production samples and non-zero offsets generated by the non-zero offset predictor based on the ADI data from the one or more previous production samples, wherein the control parameters maintain overlay error between the current layer and the one or more previous layers within a selected tolerance; and providing the values of the control parameters to the lithography tool for fabricating the current layer on the at least one production sample.