

## CLAIMS

*What is claimed is:*

1. A method comprising:
  - performing a plurality of experiments for processing a component, each experiment controlled by a recipe from a plurality of recipes that identifies parameters for manufacturing equipment;
  - performing a plurality of virtual simulations for processing the component, each simulation controlled by one recipe from the plurality of recipes;
  - obtaining a machine-learning (ML) model by training an ML algorithm using experiment results and virtual results from the virtual simulations;
  - receiving specifications for a desired processing of the component; and
  - creating, by the ML model, a new recipe for processing the component based on the specifications.
2. The method as recited in claim 1, wherein the ML model is based on a plurality of features that comprise recipe features, experiment results features, virtual result features, and metrology features.
3. The method as recited in claim 2, wherein the metrology features include one or more of imaging methods, transmission electron microscopy, typical-thickness measurement, sheet resistance, surface resistivity, stress measurement, and analytical methods used to determine layer thickness, composition, grain, or orientation.

4. The method as recited in claim 2, wherein the recipe features include workflow, gas flows, chamber temperature, chamber pressure, step durations, and radiofrequency (RF) values.
5. The method as recited in claim 2, wherein the ML model includes active process control to determine process parameters to satisfy control objectives, the input to the ML model including the control objectives for the recipe and desired active process control.
6. The method as recited in claim 1, wherein the virtual simulations are performed by a simulation tool based on behavior modeling.
7. The method as recited in claim 1, wherein the experiment results include values measured from the processing of the component, the values including one or more of lateral ratio, isotropic ratio, deposition depth, global sticking coefficient, surface dependent sticking coefficient, delay thickness, neutral-to-ion ratio, and ion angular distribution function.
8. The method as recited in claim 1, wherein each experiment is performed on a semiconductor manufacturing apparatus based on the recipe for the experiment, wherein one experiment is performed to measure effects of changing a value of one parameter from a previous recipe used in a previous experiment.
9. The method as recited in claim 1, wherein the processing the component is for a deposition process using an inhibition profile.

10. The method as recited in claim 1, wherein the processing the component is for a deposition in a 3D NAND word line (WL) fill.

11. A system comprising:

- a memory comprising instructions; and
- one or more computer processors, wherein the instructions, when executed by the one or more computer processors, cause the system to perform operations comprising:
  - performing a plurality of experiments for processing a component, each experiment controlled by a recipe from a plurality of recipes that identifies parameters for manufacturing equipment;
  - performing a plurality of virtual simulations for processing the component, each simulation controlled by one recipe from the plurality of recipes;
  - obtaining a machine-learning (ML) model by training an ML algorithm using experiment results and virtual results from the virtual simulations;
  - receiving specifications for a desired processing of the component; and
  - creating, by the ML model, a new recipe for processing the component based on the specifications.

12. The system as recited in claim 11, wherein the ML model is based on a plurality of features that comprise recipe features, experiment results features, virtual result features, and metrology features.

13. The system as recited in claim 12, wherein the metrology features include one or more of imaging methods, transmission electron microscopy, typical-thickness measurement, sheet resistance, surface resistivity, stress measurement, and analytical methods used to determine layer thickness, composition, grain, or orientation.

14. The system as recited in claim 12, wherein the recipe features include workflow, gas flows, chamber temperature, chamber pressure, step durations, and radiofrequency (RF) values.

15. The system as recited in claim 11, wherein the experiment results include values measured from the processing of the component, the values including one or more of lateral ratio, isotropic ratio, deposition depth, global sticking coefficient, surface dependent sticking coefficient, delay thickness, neutral-to-ion ratio, and ion angular distribution function.

16. The system as recited in claim 11, wherein each experiment is performed on a semiconductor manufacturing apparatus based on the recipe for the experiment, wherein one experiment is performed to measure effects of changing a value of one parameter from a previous recipe used in a previous experiment.

17. A tangible machine-readable storage medium including instructions that, when executed by a machine, cause the machine to perform operations comprising:

performing a plurality of experiments for processing a component, each experiment controlled by a recipe from a plurality of recipes that identifies parameters for manufacturing equipment;

performing a plurality of virtual simulations for processing the component, each simulation controlled by one recipe from the plurality of recipes;

obtaining a machine-learning (ML) model by training an ML algorithm using experiment results and virtual results from the virtual simulations;

receiving specifications for a desired processing of the component; and  
creating, by the ML model, a new recipe for processing the component based on the specifications.

18. The tangible machine-readable storage medium as recited in claim 17, wherein the ML model is based on a plurality of features that comprise recipe features, experiment results features, virtual result features, and metrology features.

19. The tangible machine-readable storage medium as recited in claim 18, wherein the metrology features include one or more of imaging methods, transmission electron microscopy, typical-thickness measurement, sheet resistance, surface resistivity, stress measurement, and analytical methods used to determine layer thickness, composition, grain, or orientation.

20. The tangible machine-readable storage medium as recited in claim 18, wherein the recipe features include workflow, gas flows, chamber temperature, chamber pressure, step durations, and radiofrequency (RF) values.

21. The tangible machine-readable storage medium as recited in claim 17, wherein the experiment results include values measured from the processing of the component, the values including one or more of lateral ratio, isotropic ratio, deposition depth, global sticking coefficient, surface dependent sticking coefficient, delay thickness, neutral-to-ion ratio, and ion angular distribution function.