

CLAIMS

1. A multiple-tool parameter set calibration and misregistration measurement method useful in the manufacture of semiconductor devices comprising:
- 5 using at least a first reference misregistration metrology tool using a first set of measurement parameters to measure misregistration between at least two layers on a wafer, said wafer being selected from a batch of wafers, thereby generating a first misregistration data set;
- transmitting said first set of measurement parameters and said first misregistration data set to a calibrated set of measurement parameters generator (CSMPG);
- 10 processing said first set of misregistration parameters and said first misregistration data set, using said CSMPG, thereby generating a calibrated set of measurement parameters;
- 15 transmitting said calibrated set of measurement parameters from said CSMPG to at least one initially-uncalibrated misregistration metrology tool;
- calibrating said at least one initially-uncalibrated misregistration metrology tool based on said calibrated set of measurement parameters; and
- thereafter measuring misregistration between at least two layers of at least one wafer, selected from said batch of wafers, using said at least one initially-uncalibrated misregistration metrology tool, said initially-uncalibrated misregistration metrology tool using said calibrated set of measurement parameters for said measuring.
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2. The multiple-tool parameter set calibration and misregistration measurement method according to claim 1 and wherein calibrating said at least one initially-uncalibrated misregistration metrology tool comprises calibrating a plurality of initially-uncalibrated misregistration metrology tools.
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3. The multiple-tool parameter set calibration and misregistration measurement method according to claim 1 wherein:
- 30 the method further comprises, prior to said generating of said calibrated set of measurement parameters:

- using a second reference misregistration metrology tool using a second set of measurement parameters to measure misregistration between said at least two layers on a wafer selected from said batch of wafers, thereby generating a second misregistration data set; and
- 5 transmitting said second set of measurement parameters and said second misregistration data set from said second reference misregistration metrology tool to said CSMPG) and
- processing said second set of misregistration parameters and said second misregistration data set, using said CSMPG, thereby generating said calibrated set
- 10 of measurement parameters.
4. The multiple-tool parameter set calibration and misregistration measurement method according to claim 1 and wherein processing said first set of misregistration parameters and said first misregistration data set comprises using a
- 15 CSMPG algorithm (CSMPGA).
5. The multiple-tool parameter set calibration and misregistration measurement method according to claim 4 and wherein said CSMPGA comprises a machine-learning algorithm.
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6. The multiple-tool parameter set calibration and misregistration measurement method according to claim 5 and wherein said machine-learning algorithm comprises at least one of:
- a neural network analysis;
- 25 a principle component analysis;
- a support vector machine;
- a decision tree; and
- a gaussian process.
- 30 7. The multiple-tool parameter set calibration and misregistration measurement method according to claim 4 and wherein said CSMPGA comprises a regression analysis algorithm.

8. The multiple-tool parameter set calibration and misregistration measurement method according to any of claims 1 – 7 and wherein said at least said first reference misregistration metrology tool and said at least one initially-uncalibrated misregistration metrology tool comprise scatterometry misregistration metrology tools.

9. The multiple-tool parameter set calibration and misregistration measurement method according to claim 8 and wherein said first set of measurement parameters comprises at least one of:

- 10 a linear position of a wafer stage used in misregistration measurement;
- an azimuthal orientation of a wafer stage used in misregistration measurement;
- an elevation angular orientation of a wafer stage used in misregistration measurement;
- 15 an axis along which misregistration is measured;
- a region of interest of a metrology target;
- a polarization of light used in misregistration measurement;
- wavelengths of light used in misregistration measurement;
- a bandwidth of wavelengths of light used in misregistration measurement;
- 20 an intensity of light used in misregistration measurement;
- a focal depth used in misregistration measurement;
- an apodizer used in misregistration measurement; and
- an optics channel used in misregistration measurement.

10. The multiple-tool parameter set calibration and misregistration measurement method according to claim 8 or claim 9 and wherein said first misregistration data set comprises misregistration values.

11. The multiple-tool parameter set calibration and misregistration measurement method according to any of claims 8 – 10 and wherein said first misregistration data set comprises one or more quality metrics selected from the group

consisting of: accuracy flags, tool induced shift (TIS), Qmerit, focus sensitivity, pupil 3σ , normalized pupil 3σ (MEB), throughput and precision.

12. The multiple-tool parameter set calibration and misregistration measurement method according to any of claims 1 – 7 and wherein said at least said first reference misregistration metrology tool and said initially-uncalibrated misregistration metrology tool comprise imaging misregistration metrology tools.

13. The multiple-tool parameter set calibration and misregistration measurement method according to claim 12 and wherein said first set of measurement parameters comprises at least one of:

- a linear position of a wafer stage used in misregistration measurement;
- an azimuthal orientation of a wafer stage used in misregistration measurement;
- an elevation angular orientation of a wafer stage used in misregistration measurement;
- an axis along which misregistration is measured;
- a region of interest of a metrology target;
- a numerical aperture used in misregistration measurement;
- a polarization of light used in misregistration measurement;
- wavelengths of light used in misregistration measurement;
- a bandwidth of wavelengths of light used in misregistration measurement;
- an intensity of light used in misregistration measurement;
- a focal depth used in misregistration measurement; and
- a camera used in misregistration measurement.

14. The multiple-tool parameter set calibration and misregistration measurement method according to claim 12 or claim 13 and wherein said misregistration data set comprises misregistration values.

15. The multiple-tool parameter set calibration and misregistration measurement method according to any of claims 12 – 14 and wherein said misregistration data set comprises one or more quality metrics selected from the group consisting of: accuracy flags, tool induced shift (TIS), Qmerit, focus sensitivity, contrast precision,
5 throughput and precision.

16. The multiple-tool parameter set calibration and misregistration measurement method according to claim 1 and wherein said calibrated set of measurement parameters comprises at least one of:
10 a linear position of a wafer stage used in misregistration measurement;
an azimuthal orientation of a wafer stage used in misregistration measurement;
an elevation angular orientation of a wafer stage used in misregistration measurement;
15 an axis along which misregistration is measured;
a region of interest of a metrology target;
a numerical aperture used in misregistration measurement;
a polarization of light used in misregistration measurement;
wavelengths of light used in misregistration measurement;
20 a bandwidth of wavelengths of light used in misregistration measurement;
an intensity of light used in misregistration measurement;
a focal depth used in misregistration measurement;
a camera used in misregistration measurement;
25 a polarization of light used in misregistration measurement;
an apodizer used in misregistration measurement; and
an optics channel used in misregistration measurement.

17. A multiple-tool parameter set calibration and misregistration measurement
30 system useful in the manufacture of semiconductor devices comprising:
at least a first reference misregistration metrology tool operative to use
a first set of measurement parameters to measure misregistration between at least two

- layers on a wafer, said wafer being selected from a batch of wafers, thereby generating a first misregistration data set;
- at least a first initially-uncalibrated misregistration metrology tool operative to measure misregistration between at least two layers on a wafer selected from said batch of wafers; and
- 5 a calibrated set of measurement parameters generator (CSMPG) operative to:
- receive from said at least said first reference misregistration metrology tool said first set of measurement parameters and said first misregistration data set;
- 10 process said first set of measurement parameters and set first misregistration data set, thereby generating a calibrated set of measurement parameters; and
- communicate said calibrated set of measurement parameters from said CSMPG to said at least one initially-uncalibrated misregistration metrology tool to facilitate calibrating of said at least one initially-uncalibrated misregistration metrology tool.
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18. The multiple-tool parameter set calibration and misregistration measurement system according to claim 17 and wherein said at least one initially-uncalibrated misregistration metrology tool comprises a plurality of initially-uncalibrated misregistration metrology tools and wherein said calibrated set of measurement parameters generator (CSMPG) is configured to communicate said calibrated set of measurement parameters to said plurality of initially-uncalibrated misregistration metrology tools in order to calibrate said plurality of initially-uncalibrated misregistration metrology tools.
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19. The multiple-tool parameter set calibration and misregistration measurement system according to claim 17 or claim 18 and further comprising a second reference misregistration metrology tool operative to use a second set of measurement parameters to measure misregistration between at least two layers on a wafer selected
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from said batch of wafers, thereby generating a second misregistration data set, and wherein said CSMPG is operative to:

receive from said second reference misregistration metrology tool said second set of measurement parameters and said second misregistration data set; and

5 process said second set of measurement parameters and said second misregistration data set, thereby generating said calibrated set of measurement parameters.

20. The multiple-tool parameter set calibration and misregistration measurement system according to any of claims 17 – 19 and wherein said CSMPG is configured to generate said calibrated set of measurement parameters by using a CSMPG algorithm (CSMPGA).

21. The multiple-tool parameter set calibration and misregistration measurement system according to claim 20 and wherein said CSMPGA comprises a machine-learning algorithm.

22. The multiple-tool parameter set calibration and misregistration measurement system according to claim 21 and wherein said machine-learning algorithm comprises at least one of:

a neural network analysis;
a principle component analysis;
a support vector machine;
a decision tree; and
25 a gaussian process.

23. The multiple-tool parameter set calibration and misregistration measurement system according to claim 20 and wherein said CSMPGA comprises a regression analysis algorithm.

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24. The multiple-tool parameter set calibration and misregistration measurement system according to any of claims 17 – 23 and wherein said at least one

first reference misregistration metrology tool and said at least one initially-uncalibrated misregistration metrology tool comprise scatterometry misregistration metrology tools.

25. The multiple-tool parameter set calibration and misregistration measurement system according to claim 24 and wherein said first set of measurement parameters comprises at least one of:

- a linear position of a wafer stage used in misregistration measurement;
- an azimuthal orientation of a wafer stage used in misregistration measurement;
- an elevation angular orientation of a wafer stage used in misregistration measurement;
- an axis along which misregistration is measured;
- a region of interest of a metrology target;
- a polarization of light used in misregistration measurement;
- wavelengths of light used in misregistration measurement;
- a bandwidth of wavelengths of light used in misregistration measurement;
- an intensity of light used in misregistration measurement;
- a focal depth used in misregistration measurement;
- an apodizer used in misregistration measurement; and
- an optics channel used in misregistration measurement.

26. The multiple-tool parameter set calibration and misregistration measurement system according to claim 24 or claim 25 and wherein said first misregistration data set comprises misregistration values.

27. The multiple-tool parameter set calibration and misregistration measurement system according to any of claims 24 – 26 and wherein said first misregistration data set comprises one or more quality metrics selected from the group consisting of: accuracy flags, tool induced shift (TIS), Qmerit, focus sensitivity, pupil 3σ , normalized pupil 3σ (MEB), throughput and precision.

28. The multiple-tool parameter set calibration and misregistration measurement system according to any of claims 17 – 23 and wherein said at least one first reference misregistration metrology tool and said at least one initially-uncalibrated metrology tool comprise imaging misregistration metrology tools.
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29. The multiple-tool parameter set calibration and misregistration measurement system according to claim 28 and wherein said first set of measurement parameters comprises at least one of:
- 10 a linear position of a wafer stage used in misregistration measurement;
 - an azimuthal orientation of a wafer stage used in misregistration measurement;
 - an elevation angular orientation of a wafer stage used in misregistration measurement;
 - an axis along which misregistration is measured;
 - 15 a region of interest of a metrology target;
 - a numerical aperture used in misregistration measurement;
 - a polarization of light used in misregistration measurement;
 - wavelengths of light used in misregistration measurement;
 - a bandwidth of wavelengths of light used in misregistration measurement;
 - 20 measurement;
 - an intensity of light used in misregistration measurement;
 - a focal depth used in misregistration measurement; and
 - a camera used in misregistration measurement.
- 25 30. The multiple-tool parameter set calibration and misregistration measurement system according to claim 28 or claim 29 and wherein said misregistration data set comprises misregistration values.
31. The multiple-tool parameter set calibration and misregistration measurement system according to any of claims 28 – 30 and wherein said misregistration data set comprises one or more quality metrics selected from the group consisting of:
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accuracy flags, tool induced shift (TIS), Qmerit, focus sensitivity, contrast precision, throughput and precision.

32. The multiple-tool parameter set calibration and misregistration
5 measurement system according to claim 17 and wherein said calibrated set of
measurement parameters comprises at least one of:
- a linear position of a wafer stage used in misregistration measurement;
 - an azimuthal orientation of a wafer stage used in misregistration
10 measurement;
 - an elevation angular orientation of a wafer stage used in misregistration
measurement;
 - an axis along which misregistration is measured;
 - a region of interest of a metrology target;
 - a numerical aperture used in misregistration measurement;
 - 15 a polarization of light used in misregistration measurement;
 - wavelengths of light used in misregistration measurement;
 - a bandwidth of wavelengths of light used in misregistration
measurement;
 - an intensity of light used in misregistration measurement;
 - 20 a focal depth used in misregistration measurement;
 - a camera used in misregistration measurement;
 - a polarization of light used in misregistration measurement;
 - an apodizer used in misregistration measurement; and
 - an optics channel used in misregistration measurement.