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(54) DOSE TRANSFER STANDARD DETECTOR FOR A LITHOGRAPHY TOOL

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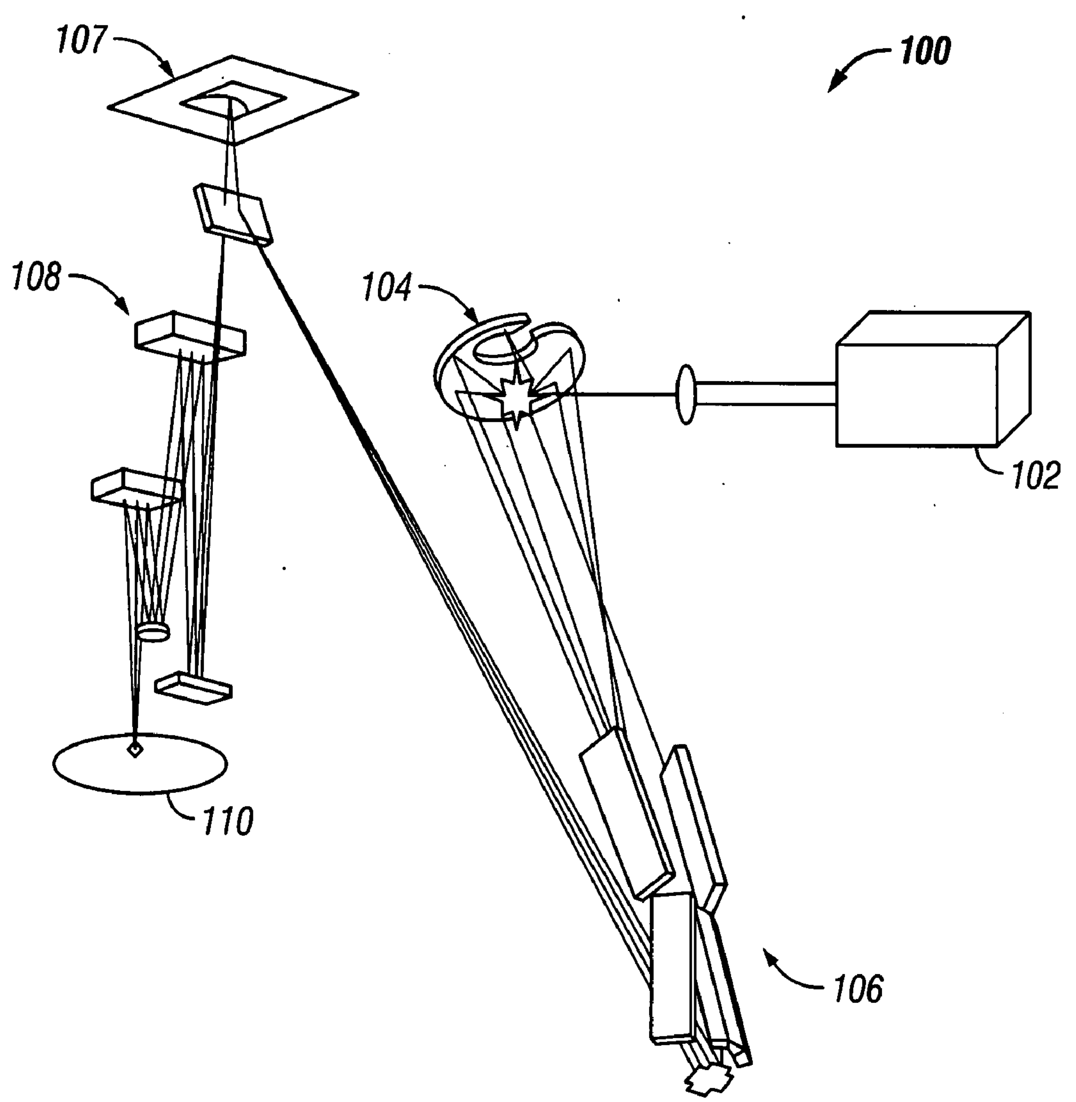
(57) **ABSTRACT**

A dose transfer standard detector measures radiation intensity and dose in a lithography tool. The lithography tool may be an Extreme Ultraviolet lithography (EUVL) tool. The dose transfer standard detector may transmit intensity and dose data to a computer, which analyzes the data. Based on the analyzed data, the lithography tool may be calibrated.



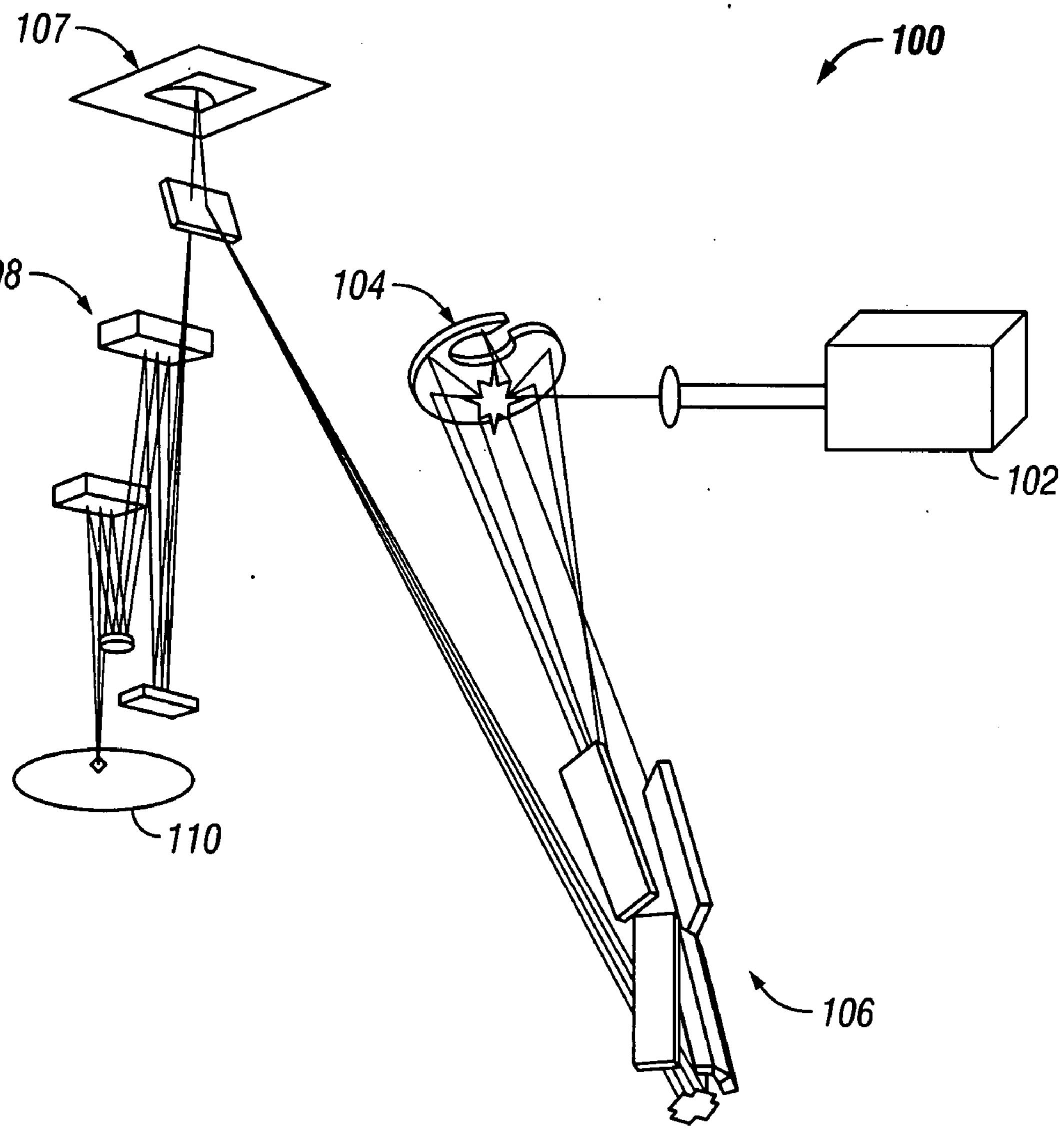


FIG. 1

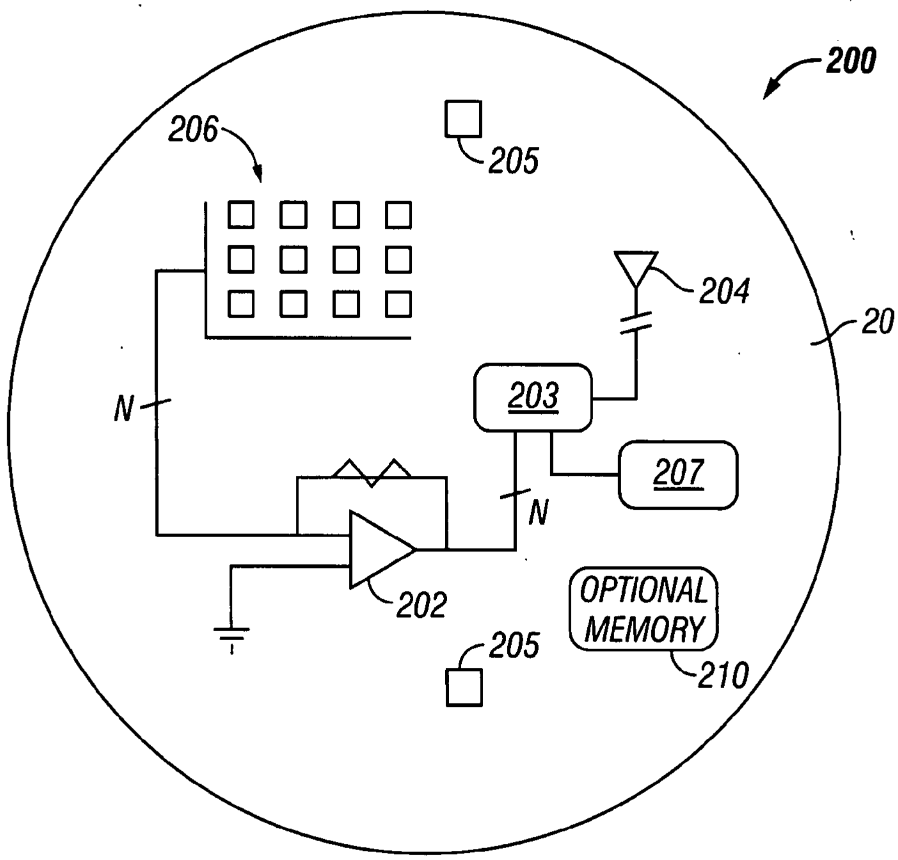

200
206
205
204
201
N
203
207
N
202
OPTIONAL MEMORY
205
210

FIG. 2

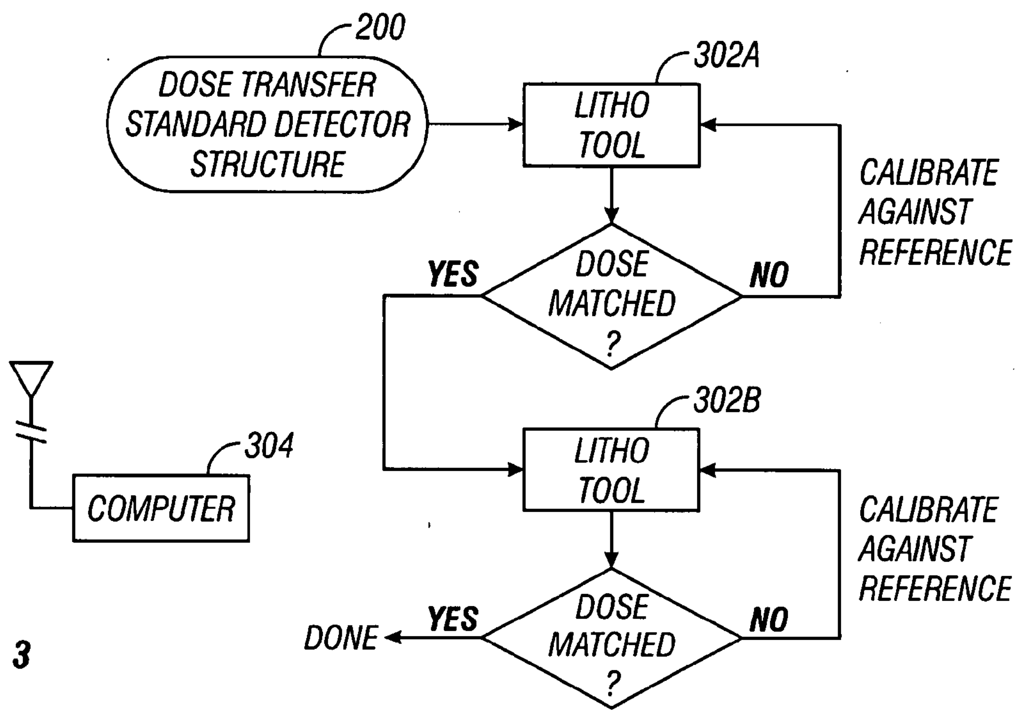

200
DOSE TRANSFER STANDARD DETECTOR STRUCTURE
302A
LITHO TOOL
CALIBRATE AGAINST REFERENCE
YES
DOSE MATCHED ?
NO
302B
LITHO TOOL
304
COMPUTER
CALIBRATE AGAINST REFERENCE
DONE
YES
DOSE MATCHED ?
NO

FIG. 3

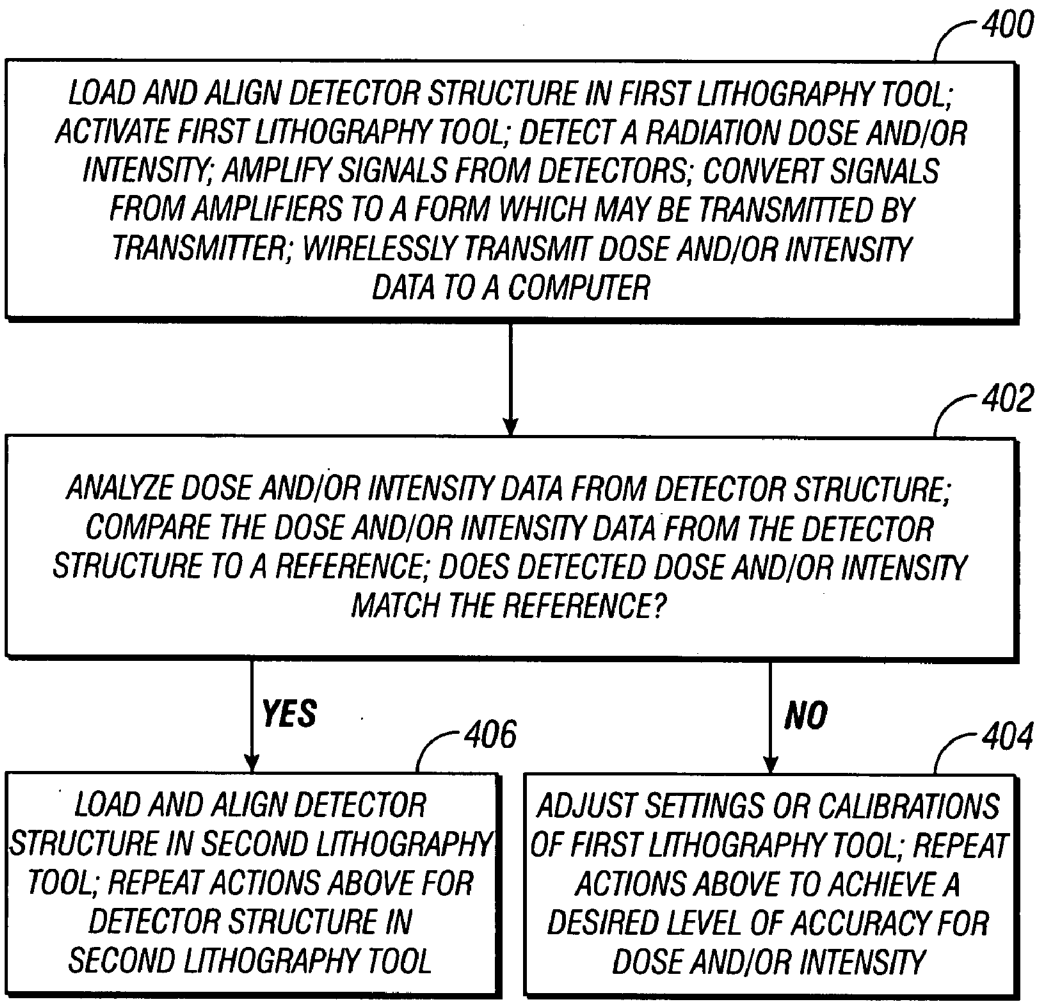

400
LOAD AND ALIGN DETECTOR STRUCTURE IN FIRST LITHOGRAPHY TOOL; ACTIVATE FIRST LITHOGRAPHY TOOL; DETECT A RADIATION DOSE AND/OR INTENSITY; AMPLIFY SIGNALS FROM DETECTORS; CONVERT SIGNALS FROM AMPLIFIERS TO A FORM WHICH MAY BE TRANSMITTED BY TRANSMITTER; WIRELESSLY TRANSMIT DOSE AND/OR INTENSITY DATA TO A COMPUTER
402
ANALYZE DOSE AND/OR INTENSITY DATA FROM DETECTOR STRUCTURE; COMPARE THE DOSE AND/OR INTENSITY DATA FROM THE DETECTOR STRUCTURE TO A REFERENCE; DOES DETECTED DOSE AND/OR INTENSITY MATCH THE REFERENCE?
YES
406
LOAD AND ALIGN DETECTOR STRUCTURE IN SECOND LITHOGRAPHY TOOL; REPEAT ACTIONS ABOVE FOR DETECTOR STRUCTURE IN SECOND LITHOGRAPHY TOOL
NO
404
ADJUST SETTINGS OR CALIBRATIONS OF FIRST LITHOGRAPHY TOOL; REPEAT ACTIONS ABOVE TO ACHIEVE A DESIRED LEVEL OF ACCURACY FOR DOSE AND/OR INTENSITY

FIG. 4

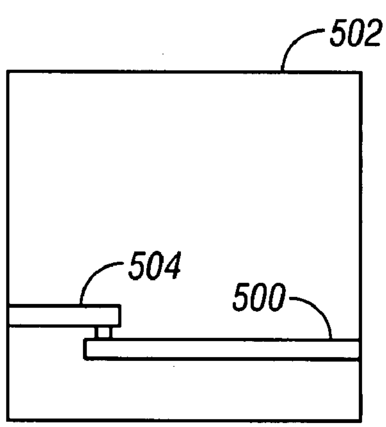

502
504
500

FIG. 5

DOSE TRANSFER STANDARD DETECTOR FOR A LITHOGRAPHY TOOL

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation application of and claims priority under 35 U.S.C. §120 to U.S. application Ser. No. 10/661,971, filed on Sep. 11, 2003.

BACKGROUND

[0002] A microchip manufacturing process may deposit various material layers on a wafer and form a photosensitive film or photoresist on one or more deposited-layers. A lithography tool may transmit light through transmissive optics or reflect light from reflective optics to a reticle or patterned mask. Light from the reticle transfers a patterned image onto the photoresist. Portions of the photoresist which are exposed to light may be removed. Portions of the wafer which are not protected by the remaining photoresist may be etched to form transistor features.

[0003] The semiconductor industry may continue to reduce the size of transistor features to increase transistor density and improve transistor performance. This reduction in transistor feature size has driven a reduction in the wavelength of light used in lithography tools to define smaller transistor features on a photoresist.

DESCRIPTION OF DRAWINGS

[0004] FIG. **1** illustrates an example of a lithography tool, such as an Extreme Ultraviolet lithography (EUVL) tool.

[0005] FIG. **2** illustrates a dose transfer standard detector structure which may be used in the lithography tool of FIG. **1**.

[0006] FIG. **3** illustrates the dose transfer standard detector structure of FIG. **2**, two lithography tools and a computer.

[0007] FIG. **4** shows a flow chart of using the dose transfer standard detector of FIG. **2**.

[0008] FIG. **5** illustrates an alternative embodiment of the dose transfer standard detector structure of FIG. **2**.

DETAILED DESCRIPTION

[0009] Extreme Ultraviolet lithography (EUVL) may use a radiation wavelength of approximately 11-15 nanometers (nm). An EUV lithography tool may print a pattern on a photoresist with dimensions which are smaller than dimensions achieved by other lithography tools. An EUV lithography tool may also be called a "lithographic exposure system," an "EUV scanner" or an "EUV stepper."

[0010] FIG. **1** illustrates an example of a lithography tool **100**, such as an Extreme Ultraviolet lithography (EUVL) tool. The lithography tool **100** may include a laser **102**, an electric discharge or laser produced plasma source **104**, condenser optics **106**, a reflective reticle **107** with a pattern, and reflective reduction optics **108**. The reticle **107** may be used to form a patterned image on an object **110**, such as a silicon wafer with a photoresist layer.

[0011] "Intensity" (milliWatts/cm^2) refers to an amount of radiation incident upon the object **110** in the lithography tool **100**. "Dose" (milliJoules/cm^2) refers to an amount of energy absorbed by the object **110** in the lithography tool **100**. A user may set radiation intensity and dose for a lithography tool according to a standard reference. The standard reference may be based on values provided by the National Institute of Standards & Technology (NIST). The intensity and dose may vary slightly from lithography tool to lithography tool even though the lithography tools have the same settings. Intensity and dose may also change ("drift") after a lithography tool is shipped or after repeated used.

[0012] It may be desirable to measure and calibrate the intensity and dose of a lithography tool. It may be desirable to compare and match the intensity and dose of two or more lithography tools.

[0013] It may be difficult to access a wafer stage of a conventional lithography tool to install hardware to measure radiation intensity and dose. A lithography tool may have a vacuum or non-vacuum wafer stage. For a lithography tool with a non-vacuum wafer stage, a person may enter the lithography tool and manually connect radiation detection hardware to the wafer stage.

[0014] For a lithography tool with a wafer stage in a vacuum, such as an EUV lithography tool, a person may have to break the vacuum to install radiation detection hardware to the wafer stage. Alternatively, a robot may be inserted in an interlock chamber connected to the vacuum to insert radiation detection hardware to the wafer stage.

[0015] The present application relates to a dose transfer (or dose transport) standard detector and techniques of using the same. The detector may address the challenges of moving a dose detector between two or more lithography tools. The detector may be easily loaded and unloaded on a wafer stage of a lithography tool, such as an extreme ultraviolet lithography (EUVL) tool. The detector may accurately measure the intensity and/or dose of one or more-vacuum or non-vacuum lithography tools. The size, shape and components of the detector may automate loading of the detector, alignment of the detector, and collection of intensity and dose data. A computer may compare data from the detector with a reference value.

[0016] FIG. **2** illustrates a dose transfer standard detector structure **200**, which may be used in the lithography tool **100** of FIG. **1**. Lithography tools may handle the dose transfer standard detector structure **200** as any other wafer. The detector structure **200** may include a wafer **201** fabricated with an array of detectors **206**, one or more amplifiers **202**, a processor **203**, a wireless transmitter **204**, a power source **207** and alignment marks **205**.

[0017] The processor **203** in FIG. **2** may be a digital signal processor available from Intel Corporation. The power source **207** in FIG. **2** may be capacitive, electrolytic, photovoltaic or some other type of power source. The alignment marks **205** allow the wafer **201** to be aligned on a wafer stage of the lithography tool **100**.

[0018] The detectors **206** in FIG. **2** may be adapted to detect radiation intensity (milliWatts/cm^2) incident upon the wafer **201** and/or dose (milliJoules/cm^2) when the wafer **201** is in the lithography tool **100**. The detectors **206** may include photodiodes. For example, the detectors **206** may include a silicon photodiode. The detectors **206** may detect extreme ultraviolet (EUV) radiation and other types of radiation. An array of detectors **206** may be used since intensity and/or dose may vary (e.g., 0.5%) over multiple detectors. An average intensity and/or dose over multiple detectors may be calculated in an embodiment.

[0019] The temperature of the wafer stage inside the lithography tool **100** may be carefully controlled such that the detectors **206**, amplifiers **202**, processor **203**, wireless transmitter **204**, and power source **207** on the wafer **201** do not experience a substantial temperature change. The array of detectors **206** may be the only components on the wafer **201** exposed to radiation in the lithography tool **100** in an embodiment.

[0020] FIG. **3** illustrates the dose transfer standard detector structure **200** of FIG. **2** being used with first and second lithography tools **302**A, **302**B and a computer **304**. The lithography tools **302**A, **302**B may be similar to the lithography tool **100** of FIG. **1**.

[0021] FIG. **4** shows a flow chart for using the dose transfer standard detector structure **200** of FIG. **2**. The detector structure **200** may be loaded and aligned on a wafer stage of the first lithography tool **302**A (FIG. **3**) at **400** in FIG. **4**. The first lithography tool **302**A may be activated to produce radiation on the detectors **206** of the wafer **201**. The array of detectors **206** may detect a radiation dose and/or intensity and produce one or more signals. One or more amplifiers **202** may amplify signals from the detectors **206**. The processor **203** may process or convert amplified signals from the amplifiers **202** to a form which may be transmitted by the transmitter **204**. The transmitter **204** may wirelessly transmit signals corresponding to dose and/or intensity data to the computer **304** (FIG. **3**) while the detector structure **200** is inside the first lithography tool **302**A.

[0022] In alternative embodiment, the detector structure **200** stores dose and/or intensity data in an optional memory **210**. When the detector structure **200** comes out of the first lithography tool **302**A, the detector structure **200** may transfer dose and/or intensity data in the memory **210** to the computer **304** wirelessly or via a physical output connector.

[0023] The computer **304** may analyze the dose and/or intensity data from the detector structure **200** at **402**. The computer **304** may collect and analyze data remotely. The computer **304**, or a user using data from the computer **302**, may compare the dose and/or intensity data from the detector structure **200** to a reference, such as a user-defined setting on the first lithography tool **302**A. The computer **304** or a user may determine if the detected dose and/or intensity substantially matches the reference.

[0024] If the computer **304**, or a user using the computer **302**, determines that the detected dose and/or intensity does not substantially match the reference, the computer **304** or user may adjust settings or calibrations of the first lithography tool **302**A at **404**. For example, the first lithography tool **302**A may be set to produce a desired dose of 10 milliJoules/cm^2 (e.g., by calibrating the laser **102** in FIG. **1**). But the detector structure **200** loaded in the first lithography tool **302**A detects an actual dose of 9.5 milliJoules/cm^2. The computer **304**, or a user using the computer **302**, may adjust the first lithography tool **302**A to 10.5 milliJoules/cm^2. The first lithography tool **302**A may then produce an actual dose of 10 milliJoules/cm^2.

[0025] The actions described above at **400** through **404** may be repeated to achieve a desired level of accuracy for dose and/or intensity of the first lithography tool **302**A.

[0026] If the computer **304**, or a user using the computer **302**, determines that the detected dose and/or intensity does substantially match the reference, the dose transfer standard detector structure **200** may be loaded and aligned on a wafer stage of the second lithography tool **302**B at **406**. The detector structure **200** may measure dose and/or intensity of the second lithography tool **302**B. The computer **304** or a user may adjust the second lithography tool's calibration based on the measured dose and/or intensity. The actions described above at **400-404** may be repeated for the second lithography tool **302**B and other lithography tools.

[0027] Thus, the detector structure **200** and computer **304** may be used to calibrate two or more lithography tools. The detector structure **200** and computer **304** may be used to match intensity and dose of two or more lithography tools.

[0028] FIG. **5** illustrates an alternative embodiment of a dose transfer standard detector structure **500**. The detector structure **500** may have detectors, amplifiers and alignment marks which are substantially similar to the detectors **206**, amplifiers **202** and alignment marks **205** of the detector structure **200** in FIG. **2**. The detector structure **500** may be inserted in a lithography tool **502**. The lithography tool **502** may have sensors or probes **504** which contact the detector structure **500** to establish an electrical connection and read intensity and/or dose data from the detector structure **500**.

[0029] A number of embodiments have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the application. For example, the structures and techniques described above may be used to measure and calibrate intensity and does for other lithography tools besides EUV lithography tools. Accordingly, other embodiments are within the scope of the following claims.

What is claimed is:

1. An apparatus comprising:

a wafer adapted to fit on a wafer stage of a lithography tool, the wafer comprising

a radiation detector to produce a signal corresponding to an amount of radiation incident on the radiation detector,

a processor in communication with the radiation detector to receive the signal, the processor to process the signal from the radiation detector, and

a wireless transmitter in communication with the processor to receive results of processing the signal and output a wireless signal based on the results.

2. The apparatus of claim 1, wherein the detector is adapted to detect a dose of radiation.

3. The apparatus of claim 1, wherein the detector is adapted to detect an intensity of radiation.

4. The apparatus of claim 1, wherein the wafer comprising comprises an array of detectors that includes the detector.

5. The apparatus of claim 1, wherein the wafer further comprises alignment marks.

6. The apparatus of claim 1, wherein the wafer further comprises an amplifier in communication with the radiation detector and the processor, the amplifier to amplify the signal from the radiation detector and communicate the amplified signal to the processor.

7. The apparatus of claim 1, wherein the wafer further comprises a power source in communication with the processor to provide power to the processor.

8. The apparatus of claim 1, wherein the wafer further comprises a memory electrically coupled to the processor, the memory to store data received from the processor, the data resulting from the processing of the signal corresponding to an amount of radiation incident on the radiation detector.

9. An apparatus comprising:

a wafer substrate sized to fit on a wafer stage of a lithography tool;

a radiation detector fabricated on the wafer substrate, the radiation detector to produce a signal indicative of an amount of radiation incident on the radiation detector;

a processor attached to the wafer substrate, the processor electrically coupled to the radiation detector, the processor to process the signal indicative of the amount of radiation incident on the radiation detector; and

a wireless transmitter fabricated on the wafer substrate, the wireless transmitter in communication with the processor to receive results of processing the signal and output a wireless signal based on the results.

10. The apparatus of claim 9, further comprising a memory to store the results of processing the signal after receipt from the processor.

11. A method comprising:

loading a wafer-shaped detector onto a wafer stage of a first lithography tool;

detecting an amount of radiation from the first lithography tool that is incident on the wafer-shaped detector; and

wirelessly transmitting a first signal indicative of the amount of radiation incident on the wafer-shaped detector to a remote receiver.

12. The method of claim 11, further comprising aligning the wafer-shaped detector on the wafer stage.

13. The method of claim 11, further comprising converting a signal indicative of the amount of radiation incident on the wafer-shaped detector to the first signal.

14. The method of claim 11, wherein said detecting the amount of radiation comprises measuring a dose of radiation.

15. The method of claim 11, wherein said detecting the amount of radiation comprises measuring an intensity of radiation.

16. The method of claim 11, further comprising amplifying an output from the detector.

17. The method of claim 11, further comprising removing the wafer-shaped detector from the wafer stage.

18. The method of claim 11, further comprising comparing the amount of radiation incident on the wafer-shaped detector to a pre-determined reference value.

19. The method of claim 18, further comprising adjusting a setting of the lithography tool if the amount of radiation incident on the wafer-shaped detector does not substantially match the pre-determined reference value.

20. The method of claim 19, further comprising repeatedly detecting an amount of radiation incident on the detector, and transmitting one or more second signals indicative of the amount of radiation detected by the repeated detections.

21. The method of claim 11, further comprising:

loading the wafer-shaped detector onto a wafer stage of a second lithography tool;

detecting an amount of radiation from the second lithography tool that is incident on the wafer-shaped detector; and

wirelessly transmitting a second signal indicative of the amount of radiation incident on the wafer-shaped detector to the remote receiver.

22. The method of claim 21, further comprising comparing the amount of radiation detected by the detector in the first lithography tool to the amount of radiation detected by the detector in the second lithography tool.

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