RETICLE OPTIMIZATION ALGORITHMS AND OPTIMAL TARGET DESIGN

BACKGROUND OF THE INVENTION

1. TECHNICAL FIELD

[0001] The present invention relates to the field of metrology, and more particularly, to overlay target design.

2. DISCUSSION OF RELATED ART

[0002] Periodic targets are widely used for overlay measurements, however, overlay targets face the continuous challenge of having to provide both detectable measurement results and compliance with produced devices, which become ever smaller and are specifically designed with respect to their production processes.

SUMMARY OF THE INVENTION

[0003] The following is a simplified summary providing an initial understanding of the invention. The summary does not necessarily identify key elements nor limits the scope of the invention, but merely serves as an introduction to the following description.

[0004] One aspect of the present invention provides a metrology target design comprising a periodic structure along a measurement direction, having a coarse pitch among periodically recurring elements, wherein each element is periodic along the measurement direction with a fine pitch among periodically recurring sub-elements, which vary in sub-element CD (critical dimension), wherein the coarse pitch is an integer multiple of the fine pitch, and wherein the target design further comprises an orthogonal periodic structure, perpendicular to the measurement direction, with an orthogonal unresolved pitch among periodically recurring bars, wherein the orthogonal unresolved pitch is smaller than a specified minimal design rule pitch.

[0005] These, additional, and/or other aspects and/or advantages of the present invention are set forth in the detailed description which follows; possibly inferable from the detailed description; and/or learnable by practice of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] For a better understanding of embodiments of the invention and to show how the same may be carried into effect, reference will now be made, purely by way of example, to the accompanying drawings in which like numerals designate corresponding elements or sections throughout.

[0007] In the accompanying drawings:

[0008] **Figure 1A** is a high level schematic illustration of a metrology target design, according to some embodiments of the invention.

[0009] **Figure 1B** is a high level schematic and highly simplified illustration of the settings of the lithography process, according to some embodiments of the invention.

[0010] **Figures 2A-2C** are high level schematic illustrations of prior art target designs.

[0011] **Figures 3** and **4** are high level schematic illustrations of metrology target designs, according to some embodiments of the invention.

[0012] **Figure 5** is a high level schematic illustration of printed metrology targets using target designs with varying width of orthogonal bars, according to some embodiments of the invention.

[0013] **Figures 6A-6C** are high level schematic illustrations of printed metrology targets, according to some embodiments of the invention.

[0014] **Figures 7A** and **7B** are high level schematic illustrations of additional measurements using targets, according to some embodiments of the invention.

[0015] **Figure 8** is a high level flowchart illustrating a method, according to some embodiments of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0016] In the following description, various aspects of the present invention are described. For purposes of explanation, specific configurations and details are set forth in order to provide a thorough understanding of the present invention. However, it will also be apparent to one skilled in the art that the present invention may be practiced without the specific details presented herein. Furthermore, well known features may have been omitted or simplified in order not to obscure the present invention. With specific reference to the drawings, it is stressed that the particulars shown are by way of example

and for purposes of illustrative discussion of the present invention only, and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for a fundamental understanding of the invention, the description taken with the drawings making apparent to those skilled in the art how the several forms of the invention may be embodied in practice.

[0017] Before at least one embodiment of the invention is explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of the components set forth in the following description or illustrated in the drawings. The invention is applicable to other embodiments that may be practiced or carried out in various ways as well as to combinations of the disclosed embodiments. Also, it is to be understood that the phraseology and terminology employed herein are for the purpose of description and should not be regarded as limiting.

[0018] Unless specifically stated otherwise, as apparent from the following discussions, it is appreciated that throughout the specification discussions utilizing terms such as "processing", "computing", "calculating", "determining", “enhancing”, "deriving" or the like, refer to the action and/or processes of a computer or computing system, or similar electronic computing device, that manipulates and/or transforms data represented as physical, such as electronic, quantities within the computing system's registers and/or memories into other data similarly represented as physical quantities within the computing system's memories, registers or other such information storage, transmission or display devices.

[0019] Overlay control is one of the main challenges of current lithography. Generally it is achieved by printing special marks, or targets on the wafer, with respect to which the overlay is measured. During the design of the mask, or reticle, the printability (process window) and aberration stability issues must be taken into account. This makes the design of the mask a very difficult task, which includes both simulations and experimental parts. One of the ways to handle the problem is the usage of the assist unprintable features on the mask (Assist Sub-Resolution Features ASRAF). These

features are not printed by themselves (as they are sub-resolved), however they improve printability of the designed structures and reduce their sensitivity to scanner's aberrations. However, the usage of assist features adds a huge number of degrees of freedom which together with the absence of generic methodology pushes the target design domain to use a trial and error approach.

[0020] Advantageously, disclosed target designs and methods make the design process of overlay targets more intuitive and predictable, by combining CD-modulation and field-modulation targets with an orthogonal periodic structure, perpendicular to the measurement direction and having an unresolved pitch.

[0021] Metrology target designs on the reticle and on the wafer, and target design and processing methods are provided. Target designs comprise coarse pitched periodic structures having fine pitched sub-elements, which vary in sub-element CD and/or height, an orthogonal periodic structure, perpendicular to the measurement direction, with an orthogonal unresolved pitch among periodically recurring bars, which provide a calibration parameter for achieving well-printed targets. Orthogonal periodic structures may be designed on the reticle and be unresolved, or be applied in cut patterns on the process layer, with relatively low sensitivity to the cut layer overlay. Designed targets may be used for overlay metrology as well as for measuring process parameters such as scanner aberrations and pitch walk.

[0022] **Figure 1A** is a high level schematic illustration of a metrology target design **100**, according to some embodiments of the invention. Illustrated is target design **100** on the reticle (photoreticle, used in lithography to define patterned layers on the wafer, also termed mask or photomask), which is used to produce a corresponding target on the wafer, which may have some different features, as explained below. Metrology target design **100** comprises a periodic structure along a measurement direction, having a coarse pitch *P* among periodically recurring elements **110**. Each element **110** is periodic along the measurement direction with a fine pitch *P1* among periodically recurring sub-elements **120**. Sub-elements **120** vary in sub-element CD (critical dimension, denoted CD1, CD2, CD3 etc.), with the coarse pitch *P* being an integer multiple of the fine pitch *P1* ($P=n \cdot P1$ with *n* being an integer, in the illustrated non-limiting example n=5). Target design **100** further comprises an orthogonal periodic structure having periodically

recurring bars **130**, perpendicular to the measurement direction, with an orthogonal unresolved pitch *P2* among periodically recurring bars **130**, which have a CD of CD(B). The unresolved orthogonal pitch *P2* is smaller than a specified minimal design rule pitch and is therefore not printed on the wafer itself, but merely help provides controllable targets, as explained below. It is noted that element **110** is denoted somewhat arbitrarily as a unit cell, and could have been chosen in different locations of metrology target design **100**.

[0023] Figure 1B is a high level schematic and highly simplified illustration of the settings of the lithography process, according to some embodiments of the invention. Targets **150** on a wafer **104** are produced using illumination from illumination source **70** which is projected through a reticle **102** (also termed mask) with target design **100** thereupon. Clearly, reticle **102** typically includes circuit design data and possibly multiple target designs **100**, relating to one, or possibly more layers of integrated circuit(s) produced on wafer **104**. The disclosed description of target designs **100** and targets **150** relates merely to these components on reticle **102** and wafer **104**, respectively, and are typically part of much more complex designs. Certain embodiments comprise lithography reticle(s) **102** comprising metrology target designs **100** disclosed herein. Certain embodiments comprise wafers **104** comprising metrology target(s) **150** produced using metrology target design(s) **100** disclosed herein, as well as metrology target(s) **150** themselves. Certain embodiments comprise target design file of metrology target(s) **150**. Certain embodiments comprise metrology overlay measurements target design file of metrology targets **150**.

[0024] Specifically, metrology target(s) **150** (part thereof illustrated schematically in **Figure 1B**) may comprise target periodic structure **150** along the measurement direction, having a target coarse pitch (P(T)) among periodically recurring target elements **151**, wherein each target element **151** is periodic along the measurement direction with a target fine pitch (P1(T)) among periodically recurring target sub-elements **155**, which vary in target sub-element CD (see in **Figure 5**), wherein target coarse pitch P(T) is an integer multiple of target fine pitch P1(T), $P(T)=n\cdot P1(T)$ for integer n. Non-limiting examples for metrology target(s) **150** are presented in **Figure 5**.

[0025] **Figures 2A-2C** are high level schematic illustrations of prior art target designs **80**. As illustrated schematically in **Figure 2A**, typical target design for overlay measurements comprises a periodic structure with elements **82** set at a pitch P. Target design on the reticle and actual target geometry are similar as all elements **82** are printed. It is noted that pitch P is large (much larger than the minimal design rule, typically larger than **100**0nm, as required for achieving optical resolution with the illumination spectrum in the visual range. However, as designs **80** leaves wide empty spaces and wide unsegmented bar **82**, they are generally process incompatible and cause significant bias with respect to devices due to asymmetric scanner aberrations.

[0026] **Figures 2B** and **2C** illustrate, respectively, prior art target designs **90**, **95** on the reticle and on the wafer, respectively. Prior art design **90** includes segmentation of wide bars **82** into a finely segmented periodic structure, having elements **92** repeating with a fine pitch P1, which yields device-like structures within the coarse pitch P. elements **92** have pitch P1 which is in the order of magnitude or even the same as device structures (minimal design rule pitch), and the required optical resolution is achieved by setting the parameters of device-like printed structures **97** to vary over the coarse pitch, as disclosed in more details in U.S. Patent Application No. 14/820917 and WIPO Application No. PCT/US16/60626, which are incorporated herein by reference in their entirety.

[0027] However, the inventors have found out that targets designs **90** have too many free parameters which influence the resulting performance, and optimizing all of them simultaneously may be a quite difficult task. For example, in target design **90**, the free parameters include the width values of each of bars **92** and make sure that all bars **92** are printed and have a large enough process window. This is a significant challenge, requiring well-calibrated simulations which are rarely available due to the difficulty of calibrating the chemistry of the resist, which is therefore typically handled by a trial and error approach. However, as the number of combinations of different CD values is huge, this prior art approach almost inapplicable. The inventors have found out that analysis is hampered by discontinuities and non-differentiable regions, which also prevent forming intuitive rules of thumb for guessing the conditions for target **95** to be well-printed.

[0028] As a solution to these difficulties, the inventors suggest, in target designs **100**, to reduce significantly the number of varying parameters in target design **100** and to use

parameters which affect the target printability in an intuitive way from a physical point of view. Since the main printability problem is connected to the luck of knowning of correct value of aerial image threshold, the inventors suggested using orthogonal bars **130** to control the printability of sub-elements **120** and their parameters, while keeping orthogonal bars **130** themselves not printed and unresolved in direction perpendicular to printed structures **155**.

[0029] **Figures 3** and **4** are high level schematic illustrations of metrology target design **100**, according to some embodiments of the invention. It is noted that **Figures 3** and **4** merely illustrate a small part of respective target designs **100**, for the purpose of explaining their design principles, namely that (i) added orthogonal pattern **130** is periodic in the perpendicular direction (to the measurement direction) and has pitch P2 (see **Figure 1A**) which is smaller than the minimal design rule pitch and is therefore unresolved by the printing tool's optical system; (ii) added orthogonal pattern **130** does not affect the positions of the diffraction orders (from elements **110**, **120** in the measurement direction) in the pupil plane of the metrology system and, correspondingly, in quasi two-beam imaging scheme provided by CD modulation targets (having different CD's for sub-elements **120**), pattern **130** does not change the position of the printed pattern in the field plane (causing no bias with respect to the devices); and (iii) by varying the width (CD(B)) of orthogonal bars **130**, the intensity of zero and first diffraction orders may be varied and may be used to easily find an appropriate value for the given parameter which provides a good printability condition. **Figure 4** illustrates schematically variants of target designs **100** having sub-elements **120** with varying heights (H1, H2, H3 etc.) and same width (CD), to which orthogonal bars **130** are added.

[0030] **Figure 5** is a high level schematic illustration of printed metrology targets **150** using target designs **100** with varying width (CD(B)) of orthogonal bars **130**, according to some embodiments of the invention. Printed metrology targets **150** illustrated in **Figure 5** were printed using target designs **100** illustrated in **Figure 1A** and **3**, as non-limiting examples. **Figure 5** demonstrates that varying the width (CD(B)) of orthogonal bars **130** results in different widths (CD's) of target sub-elements **155**, allowing simple selection of the optimal CD(B). As the resulting set of candidate targets **150** and corresponding designs **100** depends on a single parameter (CD(B)), is physically more intuitive and

allows simple fitting of other process parameters, e.g., fitting the amount of light exposed to any value of aerial image threshold - as it involves varying only one parameter in target design **100**.

[0031] It is noted that the disclosed approach of introducing orthogonal periodic structure **130**, perpendicular to the measurement direction and having an unresolved pitch, may be used as a general principle in a wide range of metrology overlay targets, and not only ones with variable CD's of fine sub-elements as shown above.

[0032] Referring back to **Figure 4**, it is noted that sub-elements **120** may be designed to have varying heights (H1, H2, H3 etc.) instead of (or possibly in addition to) having varying widths (CD1, CD2, CD3, etc.) to provide other (or additional) parameters for the optimization process. The modulation in vertical direction may be set to be unresolved and not affect the positions of diffraction orders in the pupil plane, forming no bias with respect to the devices, but still affects the mask's transmittance properties, as explained e.g., in U.S. Patent Application Publication No. 2015/0309402, incorporated herein by reference in its entirety. Target designs **100** such as disclosed in **Figure 4** may be used to add additional flexibility (e.g., widths of bars **130** and heights of sub-elements **120**) for achieving good printability conditions.

[0033] Advantageously, disclosed embodiments enable using a single parametric relaxation of the optimization process and possibly build the CD-modulation of sub-elements **120** and printed targets **150** with unified parametric sets. Moreover, disclosed embodiments provide innovative mask design capabilities including effective Aerial image threshold control using a single parametric family optimization, and a unified target design optimization relaxation using heights and/or widths of sub-elements **120**.

[0034] **Figures 6A-6C** are high level schematic illustrations of printed metrology targets **150**, according to some embodiments of the invention. It is noted that **Figures 6A-6C** merely illustrate a small part, corresponding to one period, of respective metrology target production stages **150A**, **150B** and **150**, respectively, for the purpose of explaining their design principles **Figures 6A-6C** illustrate schematically process stages **150A**, **150B** for producing targets **150**, respectively, on the wafer. Metrology targets **150** may comprise periodic structure **151** along the measurement direction, having coarse pitch (P) among periodically recurring elements **151**, wherein each element **151** is periodic along the

measurement direction with fine pitch (P1) among periodically recurring sub-elements **155** and all sub-elements **155** have the same CD. Sub-elements **155** may be cut (moving from patterns **150A** to pattern **150B** in **Figures 6A** and **6B**, respectively) by an orthogonal periodic structure **160**, perpendicular to the measurement direction, having periodically recurring cuts. The inventors have found out that the cuts may be configured to simulate CD modulation of printed target **150**, and simplify the production process. Sub-elements **155** may be configured to represent device structures without any CD variation (thereby avoiding printability problems) while the cutting process transfers these structures into effectively CD-modulated target **150** which is measurable by the metrology optical tool.

[0035] Sub-elements **155** may have varying CD's (as illustrated e.g., in **Figures 1A** and **1B**) or have a same CD. Disclosed targets **150** with sub-elements **155** with a same CD may have better printability than sub-elements **155** varying CD's and achieve an almost zero offset with respect to device structures. Respective overlay targets **150** may be used for metrology overlay measurements.

[0036] In certain embodiments, a standard device printing procedure, which includes printing of periodic gratings with minimal design rule and subsequent lines cutting in the perpendicular direction, is utilized for producing targets **150**. It is noted that as this procedure is applicable only for targets **150** in the process layer as they involve cuts, however just these targets pose a main challenge from the process compatibility point of view.

[0037] Coarse pitch (P) may be configured to be resolved by the metrology tool optics, operating e.g., above 400nm. Fine pitch (P1) may be configured to satisfy printing requirements, and cuts **160** may be configured to maintain process compatibility as well, e.g., by leaving no gaps larger than a printability threshold, e.g., 100nm. Targets **150** may be configured to have a zero, or very small, NZO (non-zero offsets) in particular when sub-elements **155** are designed as device lines with the same pitch. As the target position is fully determined by the basic lines position (of sub-elements **155**), it may have by definition NZO=0 while still providing enough contrast for the measurement optical tool.

[0038] Advantageously, while targets **150** do not suffer from printability issues, they also do not impose tough specs on the location of cutting patterns **160**, in neither measurement

direction or in the perpendicular direction, resulting in a large allowable range of overlay errors for cutting patterns **160**, of several nm, possibly even up to 10nm.

[0039] In certain embodiments, sub-elements **155** may be printed at exactly twice the minimal design rule pitch (P1=2·DR) to prevent possible overlap of cutting structures 160 with sub-elements **155** (as may happen, e.g., in cases with P1=DR and with cutting structures 160 printed using extreme dipole illumination). Configuring target 150 with P1=2·DR may maintain small or zero NZO even beyond the large range of overlay error tolerance cutting patterns **160**, as shown below in **Equation 1**, expressing the aerial intensity distribution in terms of fine pitch P1 and states for asymmetric aberration phase shift (denoted by ϕ) corresponding to illumination position in the pupil

$$I(x) = I_0 + I_1 \cdot \cos(\frac{2\pi}{P_1} x + \phi) + I_2 \cdot \cos(\frac{4\pi}{P_1} x + 2\phi) \quad \textbf{Equation 1}$$

[0040] The inventors note that the corresponding shift in target position is $\Delta x = \frac{P_1}{2\pi}\phi$, which is the same as for target **150** printed with P1 equaling minimal design rule pitch, for which the aerial intensity distribution is described in **Equations 2** (in **Equations 2**, P2=1·DR and P1=2·DR).

$$I(x) = I_0 + I_1 \cdot \cos(\frac{2\pi}{P_2} x + 2\phi) \text{ and } \Delta x = \frac{P_2}{\pi}\phi = \frac{P_1}{2\pi}\phi \quad \textbf{Equations 2}$$

[0041] Figures 7A and **7B** are high level schematic illustrations of additional measurements **170** using targets **150**, according to some embodiments of the invention. Certain embodiments may utilize targets **150** for additional measurements, such as scanner aberrations measurement **174**, pitch walk measurement **176** etc. For scanner aberrations measurement **174**, simultaneous targets **150** with segmentation pitches (fine pitch P1) in the range from minimal design rule (DR) up to twice the minimal design rule (2·DR) may be printed, cut as disclosed above and measured by overlay metrology tools **172**. The results of overlay measurements between different cells **150** corresponding to different segmentation pitches (fine pitch P1) provide a basis for scanner aberration amplitudes calculation as it is described in U.S. Patent Application No. 14/820917, which is incorporated herein by reference in its entirety. For pitch walk measurement **176**, simultaneous targets **150** may comprise two cells **150A**, each representing a periodic

structure printed on different steps of the double patterning procedure (multiple cells **150A** may be used for measuring pitch walk in a multiple patterning procedure), while other periodic structures in target **150** are transformed into CD modulation targets using the cutting procedure.

[0042] Figure 8 is a high level flowchart illustrating a method **200**, according to some embodiments of the invention. The method stages may be carried out with respect to target designs **100** and/or targets **150** described above, which may optionally be configured to implement method **200**. Method **200** may be at least partially implemented by at least one computer processor, e.g., in a metrology module. Certain embodiments comprise computer program products comprising a computer readable storage medium having computer readable program embodied therewith and configured to carry out the relevant stages of method **200**. Certain embodiments comprise target design files of respective targets designed by embodiments of method **200**. Method **200** may comprise the following stages, irrespective of their order.

[0043] Method **200** may comprise introducing (stage **210**), to a metrology target design comprising a periodic structure along a measurement direction, an orthogonal periodic structure having an orthogonal unresolved pitch, perpendicular to the measurement direction, and using (stage **220**) the metrology target design on a lithography reticle to produce a configurable metrology target with a periodic structure along the measurement direction only. Method **200** may comprise configuring (stage **230**) the metrology target design to have the periodic structure comprise periodically recurring elements at a coarse pitch with each element being periodic along the measurement direction with a fine pitch among periodically recurring sub-elements, which vary in sub-element CD, wherein the coarse pitch is an integer multiple of the fine pitch.

[0044] Method **200** may further comprise configuring a width of orthogonal periodic structure elements to optimize target printability (stage **240**). Method **200** may further comprise deriving overlay metrology measurements from metrology targets produced from the metrology target design (stage **250**).

[0045] Method **200** may comprise producing (stage **260**) a periodic structure along a measurement direction on a process layer, the periodic structure having a coarse pitch among periodically recurring elements, wherein each element is periodic along the

measurement direction with a fine pitch among periodically recurring sub-elements, which have a same CD; and cutting (stage **270**) the sub-elements by an orthogonal periodic structure, perpendicular to the measurement direction, having periodically recurring cuts.

[0046] In certain embodiments, method **200** may comprise producing the fine pitched sub-elements to have a same CD, and using the cutting to effectively simulate variable CD (stage **272**). The fine pitch may be configured to be between once and twice a minimal design rule pitch (DR), possibly, twice the DR to broaden the process window (stage **275**).

[0047] Method **200** may further comprise measuring scanner aberrations (stage **280**) using a plurality of produced metrology targets having fine pitches between one and two times a minimal design rule, measured by an overlay measurement tool.

[0048] Method **200** may further comprise comprising measuring pitch walk (stage **290**) by including in produced metrology targets, periodic cells relating to different steps of a multiple patterning procedure.

[0049] Aspects of the present invention are described above with reference to flowchart illustrations and/or portion diagrams of methods, apparatus (systems) and computer program products according to embodiments of the invention. It will be understood that each portion of the flowchart illustrations and/or portion diagrams, and combinations of portions in the flowchart illustrations and/or portion diagrams, can be implemented by computer program instructions. These computer program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or portion diagram or portions thereof.

[0050] These computer program instructions may also be stored in a computer readable medium that can direct a computer, other programmable data processing apparatus, or other devices to function in a particular manner, such that the instructions stored in the computer readable medium produce an article of manufacture including instructions

which implement the function/act specified in the flowchart and/or portion diagram or portions thereof.

[0051] The computer program instructions may also be loaded onto a computer, other programmable data processing apparatus, or other devices to cause a series of operational steps to be performed on the computer, other programmable apparatus or other devices to produce a computer implemented process such that the instructions which execute on the computer or other programmable apparatus provide processes for implementing the functions/acts specified in the flowchart and/or portion diagram or portions thereof.

[0052] The aforementioned flowchart and diagrams illustrate the architecture, functionality, and operation of possible implementations of systems, methods and computer program products according to various embodiments of the present invention. In this regard, each portion in the flowchart or portion diagrams may represent a module, segment, or portion of code, which comprises one or more executable instructions for implementing the specified logical function(s). It should also be noted that, in some alternative implementations, the functions noted in the portion may occur out of the order noted in the figures. For example, two portions shown in succession may, in fact, be executed substantially concurrently, or the portions may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each portion of the portion diagrams and/or flowchart illustration, and combinations of portions in the portion diagrams and/or flowchart illustration, can be implemented by special purpose hardware-based systems that perform the specified functions or acts, or combinations of special purpose hardware and computer instructions.

[0053] In the above description, an embodiment is an example or implementation of the invention. The various appearances of "one embodiment", "an embodiment", "certain embodiments" or "some embodiments" do not necessarily all refer to the same embodiments. Although various features of the invention may be described in the context of a single embodiment, the features may also be provided separately or in any suitable combination. Conversely, although the invention may be described herein in the context of separate embodiments for clarity, the invention may also be implemented in a single embodiment. Certain embodiments of the invention may include features from different embodiments disclosed above, and certain embodiments may incorporate elements from

other embodiments disclosed above. The disclosure of elements of the invention in the context of a specific embodiment is not to be taken as limiting their use in the specific embodiment alone. Furthermore, it is to be understood that the invention can be carried out or practiced in various ways and that the invention can be implemented in certain embodiments other than the ones outlined in the description above.

[0054] The invention is not limited to those diagrams or to the corresponding descriptions. For example, flow need not move through each illustrated box or state, or in exactly the same order as illustrated and described. Meanings of technical and scientific terms used herein are to be commonly understood as by one of ordinary skill in the art to which the invention belongs, unless otherwise defined. While the invention has been described with respect to a limited number of embodiments, these should not be construed as limitations on the scope of the invention, but rather as exemplifications of some of the preferred embodiments. Other possible variations, modifications, and applications are also within the scope of the invention. Accordingly, the scope of the invention should not be limited by what has thus far been described, but by the appended claims and their legal equivalents.

Claims

1. A metrology target design comprising a periodic structure along a measurement direction, having a coarse pitch among periodically recurring elements, wherein each element is periodic along the measurement direction with a fine pitch in the measurement direction among periodically recurring sub-elements, wherein the coarse pitch is an integer multiple of the fine pitch and in the measurement direction, and wherein one of the periodically recurring sub-elements has a first sub-element critical dimension in the measurement direction and another of the periodically recurring sub-elements has a second sub-element critical dimension in the measurement direction different from the first sub-element critical dimension, and wherein the target design further comprises an orthogonal periodic structure including periodically recurring bars having an orthogonal unresolved pitch orthogonal to the measurement direction, wherein the orthogonal unresolved pitch is smaller than a specified minimal design rule pitch such that the periodically recurring bars are configured to not be printed.

2. A lithography reticle comprising the metrology target design of claim 1.

3. A metrology target produced using the reticle of claim 2.

4. The metrology target of claim 3, comprising a target periodic structure along the measurement direction, having a target coarse pitch among periodically recurring target elements, wherein each target element is periodic along the measurement direction with a target fine pitch among periodically recurring target sub-elements, which vary in target sub-element critical dimension, wherein the target coarse pitch is an integer multiple of the target fine pitch.

5. A wafer comprising at least one metrology target of claim 3.

6. A target design file of at least one metrology target of claim 3.

7. A method comprising: introducing, to a metrology target design comprising a periodic structure along a measurement direction, an orthogonal periodic structure including periodically recurring bars having an orthogonal unresolved pitch orthogonal to the measurement direction, wherein the orthogonal unresolved pitch is smaller than a specified minimal design rule pitch such that the periodically recurring bars are configured to not be printed, and using the metrology target design on a lithography reticle to produce a configurable metrology target with a periodic structure along the measurement direction only, configuring the metrology target design to have the periodic structure comprise periodically recurring elements at a coarse pitch with each element being periodic along the measurement direction with a fine pitch among periodically recurring sub-elements wherein the coarse pitch is an integer multiple of the fine pitch, and wherein one of the periodically recurring sub-elements has a first sub-element critical dimension in the measurement direction and another of the periodically recurring sub-elements has a second sub-element critical dimension in the measurement direction different from the first sub-element critical dimension.

8. The method of claim 7, further comprising configuring a width of orthogonal periodic structure elements to optimize target printability.

9. The method of claim 8, further comprising deriving overlay metrology measurements from metrology targets produced from the metrology target design.