

SINGLE CELL GREY SCATTEROMETRY OVERLAY TARGETS AND THEIR MEASUREMENT USING VARYING ILLUMINATION PARAMETER(S)

BACKGROUND OF THE INVENTION

1. TECHNICAL FIELD

[0001] The present invention relates to the field of semiconductor metrology, and more particularly, to scatterometry overlay (SCOL) targets and metrology modules and methods for measuring them.

2. DISCUSSION OF RELATED ART

[0002] Typical SCOL metrology utilizes multiple cells having multiple periodic structures in corresponding layers, which are displaced with respect to each other by predetermined offsets to enable the derivation of the overlay from differential signals between the cells.

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 limit the scope of the invention, but merely serves as an introduction to the following description.

[0004] One aspect of the present invention provides scatterometry overlay (SCOL) measurement method comprising: generating a signal matrix by: illuminating a SCOL target at multiple values of at least one illumination parameter, and at multiple spot locations on the target, wherein the illumination is at a NA (numerical aperture) $>1/3$ yielding a spot diameter $< 1\mu$, measuring interference signals of zeroth and first diffraction orders, and constructing the signal matrix from the measured signals with respect to the illumination parameters and the spot locations on the target; and deriving a target overlay by analyzing the signal matrix.

[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] **Figures 1A and 1B** are high-level schematic illustrations of SCOL targets and respective measurement systems, according to some embodiments of the invention

[0009] **Figure 2** is a schematic illustration of a SCOL target and its measurement procedure, according to the prior art.

[0010] **Figure 3** is a high-level flowchart illustrating a method, according to some embodiments of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0011] 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.

[0012] 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.

[0013] 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. In certain embodiments, illumination technology may comprise, electromagnetic radiation in the visual range, ultraviolet or even shorter wave radiation such as x rays, and possibly even particle beams.

[0014] Embodiments of the present invention provide efficient and economical methods and mechanism for scatterometry overlay (SCOL) metrology measurements and thereby provide improvements to the technological field of semiconductor metrology. Scatterometry overlay (SCOL) measurement methods, systems and targets are provided to enable efficient SCOL metrology with in-die targets. Methods comprise generating a signal matrix by: illuminating a SCOL target at multiple values of at least one illumination

parameter, and at multiple spot locations on the target, wherein the illumination is at a NA (numerical aperture) $>1/3$ yielding a spot diameter $<1\mu$, measuring interference signals of zeroth and first diffraction orders, and constructing the signal matrix from the measured signals with respect to the illumination parameters and the spot locations on the target; and deriving a target overlay by analyzing the signal matrix. The SCOL targets may be reduced to be a tenth in size with respect to prior art targets, as less and smaller target cells are required, and be easily set in-die to improve the accuracy and fidelity of the metrology measurements. The small spots, the use of varying illumination parameters and quick spot scanning methods, enable using single cells instead on pairs of cells with opposite predefined offsets, and enable reducing the cell size together with the spot size reduction.

[0015] **Figures 1A and 1B** are high-level schematic illustrations of a SCOL target **110** and its measurement system **100**, according to some embodiments of the invention. System **100**, e.g., a metrology system or module therewithin, may be configured to illuminate SCOL target **110** having periodic structures **120A**, **120B** (e.g., gratings) using a large NA (numerical aperture) illumination unit **130** (e.g., having $NA > 1/3$ such as any of $NA = 0.4, 0.5, 0.6, 0.7, 0.8, 0.9$, or other values— with orders $-1, 0$ and $+1$ at least partly overlapping **145A** in the pupil plane) resulting in corresponding small illumination spots **136**, e.g., smaller than 1μ , or possibly between any of $250\text{-}1000\text{nm}$ or $600\text{-}1000\text{nm}$. In **Figure 1A**, SCOL target **110** is illustrated in schematic cross-section view, with intermediate layers between top periodic structure **120A** and bottom periodic structure **120B**, and notation of illumination **135**, reflection signal (R_0 denoting the zeroth order) and ± 1 order diffracted signals **145**, denoted by $T_{\pm 1}$ and $B_{\pm 1}$ for top and bottom ± 1 diffraction orders, respectively. In **Figure 1B**, SCOL target **110** is illustrated in schematic top view, and may have an offset (not shown) between periodic structures **120A**, **120B**.

[0016] System **100** may be configured to illuminate SCOL target **110** at a plurality of spot locations **136** on target **110**, which may be stepped along the measurement direction(s) of periodic structure(s) **120A**, **120B** of SCOL target **110** and possibly scanned along the elements of periodic structure(s) **120A**, **120B** (perpendicular to the measurement direction) for averaging the measured signals. Spot locations **136** may be selected to be within a pitch

of periodic structure(s) **120A**, **120B** of SCOL target **110**, as illustrated schematically in **Figure 1B**. It is noted that spot locations **136** may be spread over two or more pitches, yet at least two of the spot locations should be not equivalent with respect to the target periodicity, to yield non-equivalent signals for analysis. Selecting spot locations **136** within one (or two) target pitches enables a significant reduction in target size, compared with prior art that requires many target pitches to be covered by the large prior art illumination spot.

[0017] System **100** further comprises a measurement unit **140** with pupil plane sensor(s) configured to measure a corresponding plurality of measurement signals **145** from multiple spot locations **136** on target **110**. Signals **145** comprise interference signals of zeroth and first order diffractions components of the illumination from each spot location **136**, as illustrated schematically by overlaps **145A** in **Figures 1A** and **1B**. Such interference is due to using small illumination spots **135** and measurement may utilize changes in signal intensity to isolate or evaluate first order signal fluctuations from background zeroth order reflections. SCOL targets **110** may comprise a single cell, from which all signals may be derived and the corresponding overlay may be calculated. Analysis of signals **145** may be carried out as taught by U.S. Patent Application Publication No. 2017/0268869, which is incorporated herein by reference in its entirety.

[0018] System **100** may be configured to carry out illumination **130** at least at two different illumination parameters (denoted as “grey” SCOL), e.g., using multiple different wavelengths (e.g., three or more), using different focus and/or positions (possibly involving scanning the target), different polarizations, etc., and to derive the target overlay from an analysis of measured signals **145** with respect to the spot locations on target **110** and the illumination parameters. It is noted that one, two, three or more illumination parameters may be used in the measurements, in certain embodiments, using three illumination parameter values was found to be optimal in some cases with respect to measurement and overlay derivation complexities.

[0019] System **100** further comprises a processing unit **155** configured to construct a signal matrix **150** from measured signals **145** with respect to the illumination parameters and the spot locations on target **110**, and to derive the target overlay by analyzing signal matrix **150**. As measurements employ multiple small spots **135**, having different illumination characteristics, to multiple spot locations **136** on target **110** that yield interfered (mixed) diffraction orders from which corresponding signals **145** - resulting signal matrix **150** may be used to derive and analyze the signals with respect to spot locations **136** and illuminating characteristics to derive the target overlay.

[0020] System **100** may be further configured to calibrate signal matrix **150** by performing or simulating measurements of SCOL targets with known overlay values. For example, multiple reference targets, possibly on reference wafer(s), with known overlays may be measured by system **100** and the measurements may be used to generate a model relating measurement results to the known overlays. Alternatively or complementarily, simulations may be used to suggest relations between overlays and signals, and possibly to optimize the illumination parameters used (e.g., wavelengths values, other illumination parameters) as well as spot size and NA, stepping and scanning methods and parameters of spots **135** over target **110** etc. System **100** may be further configured to create a model of signal matrix **150** with respect to spot locations **136**, illumination parameters and target overlays. Calibration may be carried out in a training phase or on-the-fly. Scanning targets **110** with small spots **135** may be carried out, e.g., by scanning over a length scale of one target pitch (or, e.g., two target pitches), e.g., smaller than 1μ .

[0021] In certain embodiments, target **110** may be designed to have periodic structures with specified pitches along two measurement directions, and system **100** may be configured to derive measurements using the same cell for both directions, with corresponding signal matrices **150** derived for each direction, possibly simultaneously, and analyzed to derive respective overlays as disclosed above.

[0022] In various embodiments, a formalism may be used to derive the relation between the overlay and the measurement results with multiple illumination parameters, based e.g.,

on electromagnetic modelling and/or simulation of optical path differences (OPDs), that relate changes in the strength of the diffracted fields with the changing illumination parameters – with respect to the overlay. Following corresponding analysis, simulation and/or training, direct relations may be established between the overlay and the measurement results.

[0023] For example, the inventors have noted that the ratio of the sum of differential signals to the difference of signal sums in the two measurement wavelengths depends only on the difference between the OPDs at the two wavelengths (or generally at the two measurement conditions), and not on the OPDs themselves. Therefore, in certain embodiments, this expression may be a stable parameter between process variations. For example, the measurement signals may be modelled while maintaining a relation between the illumination parameters and intensity measurements and/or accuracy metrics associated therewith.

[0024] In certain embodiments, landscape shifts with process variation may be utilized to derive overlays and/or to decouple between the overlay and target asymmetries, landscapes comprising an at least partially continuous dependency of at least one metrology metric on at least one parameter, as taught e.g., by U.S. Application Publication Nos. 2016/0313658 and 2018/0023950, incorporated herein by reference in their entirety. For example, measurements may be carried out at flat and resonant regions of the landscape to derive the overlay (and/or process variation). In certain embodiments, opposite predetermined offsets may be set in single target at different sites on the wafer, and the derivation may take into account the relative effects of these intended offsets.

[0025] In certain embodiments, a training phase may include measuring the metrology measurement recipe over multiple sites across the wafer, and modelling from the measurements, at least partly, the relation between the changes in illumination parameters and the changes in OPDs – which may then be used to derive the overlays. For example,

certain wavelength ranges may be used for the measurements, with respect to certain ranges of changes in OPD.

[0026] **Figure 2** is a schematic illustration of a SCOL target **80** and its measurement procedure **90**, according to the prior art. Prior art SCOL targets **80** typically comprise at least two cells **80A**, **80B** in each measurement direction, which comprise two or more periodic structures in corresponding layers, which are displaced with respect to each other by opposite predetermined offsets $+f_0$ and $-f_0$, illustrated schematically. Cells **80A**, **80B** are used to extract the (unintended) overlay between the periodic structures from measured diffraction signals from cells **80A**, **80B**. Measurements **90** are carried out by providing illumination and measurement conditions which prevent overlap of the diffraction orders **65** (e.g., $+1^{\text{st}}$, -1^{st}) with the reflected illumination (zeroth order) at the pupil plane of a respective sensor **60**. The required prior art illumination conditions (of illumination unit **70**) include a small numerical aperture (NA) which creates a large illumination spot **75** on cells **80A**, **80B**, and provides the required diffraction order isolation on sensor **60**. For example, small illumination NA (e.g., $\text{NA}=0.1, 0.2, 0.3$ or other values smaller than about a third – with orders $-1, 0$ and $+1$ not overlapping in the pupil plane) may be configured to result in illumination spot **75** being 1μ or more, to ensure scattered orders separation. The overlay is then calculated from the differential signal between the cells **62**. It is noted that large illumination spot **75** requires prior art cells **80A**, **80B** to be large, and the minimal requirement of two cells per direction (for providing the opposite predetermined offsets $\pm f_0$) further increases the size of prior art SCOL targets **80**, reaching typically e.g., $8\mu \times 8\mu$ (cell size) or larger.

[0027] Advantageously, the inventors have found out that in contrast to prior art, a single cell approach to SCOL is attainable using a small illumination spot and multiple illumination parameter(s) values, such as multiple wavelengths instead of using prior art cell pairs with opposite predetermined offsets. For example, modification of illumination parameters was found to be related to fluctuation in measured signal intensities (and/or related accuracy metrics), which were then used to derive data concerning the respective measured targets. Advantageously, the disclosed approach reduces significantly the real

estate required for the metrology target, possibly enabling in-die metrology – due to using a single cell instead of two cells for each measurement direction and as the cells can be made smaller due to the use of a small illumination spot. It is noted that that significant reduction in real estate is achieved at the cost of requiring measurements with multiple measurement parameters and possibly target scanning (which may take longer and require illumination modification) and possibly at the cost of making the calibration more empirical in nature, as the derivation of the overlay from the measurement data is less straightforward than in the prior art. The derivation of the overlay from the calibrated measurements may be carried out analytically, e.g., using simulations, in a training phase, using calibration wafer(s) and/or using simulation. It is emphasized though, that following initial calibration and training, the derivation of the overlay is expected to be at least as fast as in the prior art.

[0028] According to initial modelling, in certain embodiments, SCOL targets **110** may be significantly smaller than prior art SCOL targets **80** - due to their reduction to one cell **115** for each measurement direction (or possibly using the same cell for both directions) and optional reduction of cell size due to using smaller spot **135**. For example, single cell targets **110** may be four or less pitch bars (periodic structure elements) wide, possibly one or two pitch bars wide. As a result, SCOL targets **110** may be down to ten times smaller than prior art SCOL targets **80** (e.g., measure $2\mu\text{x}2\mu$ or smaller, vs. $8\mu\text{x}8\mu$ or larger, respectively). Periodic structures **120A**, **120B** in multiple layers of SCOL target **110** may be aligned, as prior art predefined offsets may not be necessary is the current invention (they are used in the prior art to provide differential signal **62**, which may be presently replaced by signal matrix **150**). It is noted that multiple illumination characteristics may be used in various embodiments to extract the overlay from the different responses of periodic structures **120A**, **120B**, rather than the predetermined offsets used in the prior art.

[0029] Advantageously, disclosed small SCOL targets **110** are readily designed as in-die targets or marks, providing higher metrology accuracy and fidelity with respect to the semiconductor devices on the wafer.

[0030] In various embodiments, disclosed systems **100**, targets **110** and methods **200** may increase the illumination NA to provide signals including zeroth and first order mixing, which is utilized by spot scanning to detect the resulting modulation (as the spot is scanned and/or as the illumination characteristics and changed) in the overlapping orders over the pupil area. Measurements with multiple wavelengths include information for deriving the overlay without the need for an additional cell. System **100** may implement fast spot scanning and fast wavelength switching so that the data required for the disclosed measurements is collected with minimal or no MAM (move-acquire-measure) penalty relative to specified requirements, and thereby enable in-die small targets required by customers.

[0031] **Figure 3** 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 SCOL targets **110** and/or measurement systems **100** 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 metrology measurements derived by embodiments of method **200**. Method **200** may comprise the following stages, irrespective of their order.

[0032] Scatterometry overlay (SCOL) measurement method **200** comprises generating a signal matrix (stage **240**) by: illuminating a SCOL target, wherein the illumination is at a large NA (numerical aperture) $> 1/3$ yielding a small spot diameter $< 1\mu$ (stage **210**), at multiple spot locations on the target (stage **220**), and at multiple values of at least one illumination parameter (stage **230**), e.g., three or more wavelengths, and measuring interference signals of zeroth and first diffraction orders (stage **215**). The signal matrix is then constructed from the measured signals with respect to the illumination parameters and the spot locations on the target (stage **240**). Method **200** further comprises deriving a target

overlay by analyzing the signal matrix, e.g., from an analysis of the measured signals with respect to the spot locations on the target and the illumination parameters (stage 250).

[0033] The SCOL target may comprise at least one periodic structure and the multiple spot locations may be within one pitch (or two pitches) of the at least one periodic structure, so that non-equivalent spot locations with respect to the periodicity of the target are used. The spot locations on the target may be set within the target pitch along a measurement direction of the at least one periodic structure, changing the spot locations within the target pitch (stage 222), and the measured signal may be averaged in a direction perpendicular to the measurement direction, e.g., by scanning the spots along the target elements (stage 224).

[0034] In certain embodiments, SCOL measurement method 200 may further comprise calibrating the signal matrix by performing or simulating measurements of SCOL targets with known overlay values (stage 260).

[0035] In certain embodiments, SCOL measurement method 200 may further comprise carrying out a training phase of measuring a corresponding metrology measurement recipe over multiple sites across the wafer (stage 270).

[0036] In certain embodiments, SCOL measurement method 200 may further comprise creating a model of the signal matrix with respect to the spot locations, illumination parameters and target overlays (stage 280).

[0037] In certain embodiments, method 200 as a SCOL target design method may comprise designing the SCOL target as a single cell target and/or as being $2\mu\text{x}2\mu$ or smaller, and possibly placed in-die on a corresponding wafer. In certain embodiments, method 200 may further comprise configuring the periodic structures of the target to be aligned and/or be at most four, three, or two pitch bars (periodic structure elements) wide, possibly even one pitch wide. Certain embodiments comprise target design files of SCOL targets 110 and/or SCOL targets designed by the SCOL target design method.

[0038] 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.

[0039] 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.

[0040] 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.

[0041] 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.

[0042] 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.

[0043] 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

What is claimed is:

1. A scatterometry overlay (SCOL) measurement method comprising:
generating a signal matrix by:
 illuminating a SCOL target at multiple values of at least one illumination parameter, and at multiple spot locations on the target, wherein the illumination is at a NA (numerical aperture) $> 1/3$ yielding a spot diameter $< 1\mu$,
 measuring interference signals of zeroth and first diffraction orders, and
 constructing the signal matrix from the measured signals with respect to the illumination parameters and the spot locations on the target, and
deriving a target overlay by analyzing the signal matrix.
2. The SCOL measurement method of claim 1, wherein the SCOL target comprises at least one periodic structure and the multiple spot locations are within a pitch of the at least one periodic structure.
3. The SCOL measurement method of claim 2, further comprising setting the spot locations on the target within the target pitch along a measurement direction of the at least one periodic structure, and averaging the measured signal in a direction perpendicular to the measurement direction.
4. The SCOL measurement method of any one of claims 1-3, wherein the at least one illumination parameter comprises an illumination wavelength, and the multiple values thereof comprise at least three illumination wavelengths.
5. The SCOL measurement method of any one of claims 1-4, further comprising calibrating the signal matrix by performing or simulating measurements of SCOL targets with known overlay values.
6. The SCOL measurement method of claim 5, further comprising creating a model of the signal matrix with respect to the spot locations, illumination parameters and target overlays.
7. A computer program product comprising a non-transitory computer readable storage medium having computer readable program embodied therewith, the computer

- readable program configured to carry out the SCOL measurement method of any one of claims 1-6.
8. A metrology module comprising the computer program product of claim 7.
 9. Metrology measurements of the SCOL targets, carried out by the SCOL measurement method of any one of claims 1-6.
 10. A SCOL target comprising a single cell having periodic structures at a plurality of layers and measuring $2\mu\text{x}2\mu$ or smaller.
 11. The SCOL target of claim 10, wherein the periodic structures are at most four pitch bars wide.
 12. The SCOL target of claim 11, wherein the periodic structures are two pitch bars wide.
 13. The SCOL target of any one of claims 10-12, placed in-die on a corresponding wafer.
 14. A scatterometry overlay (SCOL) measurement system comprising:
 - an illumination unit configured to illuminate a SCOL target at multiple values of at least one illumination parameter, and at multiple spot locations on the target, wherein the illumination is at a NA (numerical aperture) $>1/3$ yielding a spot diameter $<1\mu$,
 - a measurement unit configured to measure interference signals of zeroth and first diffraction orders, and
 - a processing unit configured to construct a signal matrix from the measured signals with respect to the illumination parameters and the spot locations on the target, and derive a target overlay by analyzing the signal matrix.
 15. The SCOL measurement system of claim 14, further configured to set the spot locations on the target within a target pitch along a measurement direction of the at least one periodic structure, and averaging the measured signal in a direction perpendicular to the measurement direction by scanning the SCOL target along elements of the at least one periodic structure.
 16. The SCOL measurement system of claim 14 or 15, wherein the at least one illumination parameter comprises an illumination wavelength, and the multiple values thereof comprise at least three illumination wavelengths.

17. The SCOL measurement system of any one of claims 14-16, further configured to calibrate the signal matrix by performing or simulating measurements of SCOL targets with known overlay values.
18. The SCOL measurement system of claim 17, further configured to create a model of the signal matrix with respect to the spot locations, illumination parameters and target overlays.