(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
4 December 2014 (04.12.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/193983 Al

(51) International Patent Classification:
H01L 21/66 (2006.01)

(21) International Application Number:
PCT/US2014/039833

(22) International Filing Date:
28 May 2014 (28.05.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/828,578 29 May 2013 (29.05.2013) US

(71) Applicant: KLA-TENCOR CORPORATION [US/US]; Legal Department, One Technology Drive, Milpitas, California 95035 (US).

(72) Inventor: NURIEL, Amir; 34 Yarden Street, 2068 101 St. Yokne'am (IL).

(74) Agent: MCANDREWS, Kevin; KLA-TENCOR CORP., Legal Department, One Technology Drive, Milpitas, California 95035 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available):* AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available):* ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) Title: MULTI-LAYERED TARGET DESIGN

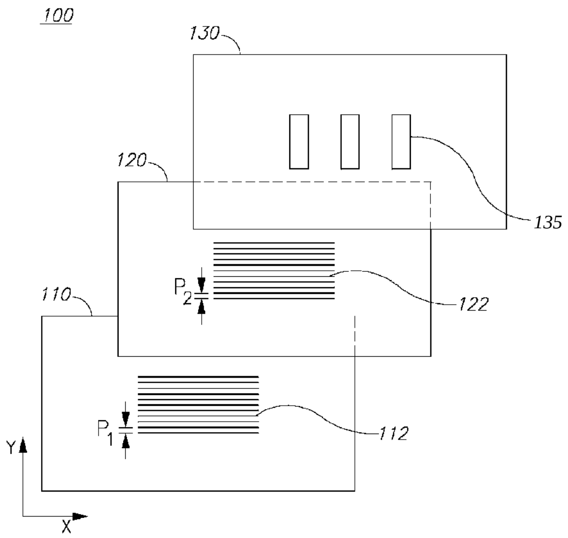


Figure 1A

(57) Abstract: Multi-layered targets, design files and design and production methods thereof are provided. The multi-layered targets comprise process layers arranged to have parallel segmentation features at specified regions, and target layer comprising target elements which are perpendicular to the parallel segmentation features of the process layers at the specified regions.

WO 2014/193983 A1

MULTI-LAYERED TARGET DESIGN

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 61/828,578 filed on May 29, 2013, which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

1. TECHNICAL FIELD

[0002] The present invention relates to the field of metrology, and more particularly, to metrology targets.

2. DISCUSSION OF RELATED ART

[0003] Metrology targets are designed to enable the measurement of parameters that indicate the quality of wafer production steps and quantify the correspondence between design and implementation of structures on the wafer. Metrology targets as specific structures optimize the requirements for device similarity and for optical measurability. Compliance of targets to semiconductor manufacturing design rules contributes to accurate production of the targets but may reduce the optical measurability of the targets.

[0004] U.S. Patent Publication No. 2012/0033215 and U.S. Patent No. 8,243,273, which are incorporated herein by reference in their entirety, disclose adding dummyfill to a target design to improve compliance with design rules.

SUMMARY OF THE INVENTION

[0005] One aspect of the present invention provides a multi-layered target comprising at least two process layers arranged to have parallel segmentation features at specified regions, and at least one target layer comprising target elements which are perpendicular to the parallel segmentation features of the process layers at the specified regions.

[0006] 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

[0007] 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.

[0008] In the accompanying drawings:

[0009] Figure 1A is a high level schematic illustration of multi-layered targets, according to some embodiments of the invention.

[0010] Figure IB is a high level schematic illustration of target elements and their respective peripheries, according to some embodiments of the invention.

[0011] Figures 2A and 2B are high level schematic illustrations of an exemplary multi-layered target and its layers respectively, according to some embodiments of the invention.

[0012] Figures 3A and 3B are high level schematic illustrations of an exemplary multi-layered target and its layers respectively, according to some embodiments of the invention.

[0013] Figures 4A and 4B are high level schematic illustrations of an exemplary multi-layered target and its layers respectively, according to some embodiments of the invention.

[0014] Figure 5 is a high level flowchart illustrating a method, according to some embodiments of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0015] Prior to the detailed description being set forth, it may be helpful to set forth definitions of certain terms that will be used hereinafter.

[0016] The terms "metrology target" or "target" as used herein in this application, are defined as structures designed or produced on a wafer which are used for metrological purposes. The term "target element" as used herein in this application, is defined as a feature in the metrology target such as individual target areas or boxes, grating bars etc. Target elements may be full or empty (gaps), and may also be segmented, i.e., may comprise multiple smaller features which cumulatively constitute the target element. A target is referred to as comprising target elements, each "target element" being a feature of the target that is to be distinguished from its background, the "background" being a wafer area proximate to a target element on the same or on a different layer (above or below the target element). Specifically, the term "periphery" of a target element refers to the immediate layer around the target element in the same layer. The term "specified region" as used herein in this application, is defined as a region of the target which surrounds a target element, i.e. the specified region includes the target element itself and its immediate background.

[0017] The terms "layer", "process layer" and "target layer" as used herein in this application, are defined as any of the layers used in a photolithography process in any of its steps. The term "target layer" is used to distinguish a layer with target elements which are to be measured from other layer, yet "process layers" may also hold target elements which may be measured sequentially of simultaneously with respect to target elements of the target layer. Hence, the notation of layers as process layers and target layers is not to be understood as limiting the invention but as merely helping to clarify the target structure and design principles. Examples for layers, which are used in a non-limiting manner in the present disclosure include oxide or oxide diffusion (OD) layers, polysilicon (poly) layers and contact layers.

[0018] The term "periodic structure" as used in this application refers to any kind of designed or produced structure in at least one layer which exhibits some periodicity. The periodicity is characterized by its pitch, namely its spatial frequency. For example, a bar as a target element may be produced as a group of spaced parallel lines, thereby reducing the minimal feature size of the element and avoiding monotonous regions in the target.

[0019] The term "segmentation features" as used in this application refers to any details of an area on a layer which are used to prevent the area from being continuously full or continuously empty (which may be referred to as "dummyfill") , with respect to the order of magnitude of typical device features. In particular, such details are commonly introduced to enhance the producibility of the target. Often these details - the segmentation features - are introduced as parallel lines having pitch values which are process compatible. The term "parallel segmentation features" is defined as any area filling details which are at least to some extent parallel in a certain direction.

[0020] With specific reference now to the drawings in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of the preferred embodiments 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.

[0021] 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 or of being practiced or carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein is for the purpose of description and should not be regarded as limiting.

[0022] Figure 1A is a high level schematic illustration of multi-layered targets 100, according to some embodiments of the invention. Multi-layered targets 100 comprise at least two process layers 110, 120 arranged to have parallel segmentation features 112, 122 (respectively) at specified regions, and at least one target layer 130 comprising target elements 135 which are perpendicular to parallel segmentation features 112, 122 of process layers 110, 120 (respectively) at the specified regions. The specified regions themselves are understood as the areas of target elements 135 and their immediate peripheries with respect to layers 110, 120, 130 in multi-layered target 100. The at least one target layer may comprise a plurality of target layers, each having target elements at distinct specified regions. Process layers may also comprise target elements at distinct specified regions. The terms process layer and target layer are used for explanatory reasons and are not to be understood as limiting the possible locations for target elements. Moreover, during the metrology measurements layer may change their roles as process layers and target layers, depending on which target is actually measured.

[0023] Figure IB is a high level schematic illustration of target elements 135 and their respective peripheries 136, according to some embodiments of the invention. Target elements 135 may be, exemplified from left to right in Figure IB, full bars and/or gap bars (i.e., featureless areas within a periphery with features) and/or bars segmented perpendicularly to the parallel segmentation features of the process layers at the specified regions (e.g., 112 and 122 in 110 and 120, respectively) and/or bars segmented in parallel to the parallel segmentation features of the process layers at the specified regions (e.g., 112 and 122 in 110 and 120, respectively).Periphery 136 of target elements 135 may be, exemplified in Figure IB in arbitrary and non-limiting relationship to target elements 135, empty, full, or segmented parallel or perpendicular to the parallel segmentation features, as long as optical contrast between target element 135 and its periphery 136 is maintained when using specified measurement configuration (e.g., with or without polarization measurements).

[0024] Parallel segmentation features (e.g., 112, 122) of process layers (e.g., 110, 120, respectively) are configured to have pitches (e.g., p_1, p_2, respectively) which do not form a Moire pattern between the process layers, as such a pattern may increase measurement inaccuracy or may generate false measurements altogether. Pitches pi and p2 may be equal, have an integer ratio, or at least have a Moire pattern pitch which does not disturb the measurements (e.g., pi and p_2 may have a large enough common divider or a ratio of small integers as the pitch ratio).

[0025] In certain embodiments, target elements 135 may be bars segmented in parallel to parallel segmentation features 112, 122 of process layers 110, 120 at the specified regions. In such cases, the bar segmentation pitch is selected not to produce a Moire pattern with the parallel segmentation features (e.g., share a pitch value or have a pitch that forms an integral ratio with the pitch(es) of the parallel segmentation features. While the bar itself is perpendicular to the parallel segmentation features and hence produces a measurement along the same direction as the parallel segmentation features, it may be segmented at a pitch which creates a Moire pattern with the parallel segmentation features (in a direction perpendicular to the parallel segmentation features, i.e., perpendicular to the direction measurement). While such Moire pattern is not useful for the measurement itself, it may be used or configured to facilitate ROI placement or target acquisition.

[0026] Figures 2A and 2B are high level schematic illustrations of a multi-layered target 100 and its layers 110, 120, 130, respectively, according to some embodiments of the invention. Figures 2A and 2B exemplify in a non-limiting manner process layer 110 (e.g., an oxide diffusion (OD) layer) having segmentation features 112A, 112B which may differ in different regions of layer 110; process layer 120 (e.g., a polysilicon (poly) layer) having segmentation features 122A, 122B which may differ in different regions of layer 120 but are parallel to segmentation features 112A, 112B (respectively) in specified overlapping regions in which segmentation features of layers 110 and 120 are parallel to each other; and target layer 130 (e.g., a contact layer) having target elements 135 in the specified regions in which segmentation features of layers 110 and 120 are parallel to each other. Layers 110, 120, 130 are shown separately in Figure 2B and overlapping in Figure 2A. It is noted that target elements 135 are perpendicular to parallel segmentation features of layer 110, 120 in each of the target quartiles.

[0027] It is noted that the illustrated identities and order of layers 110, 120 and 130 is non-limiting and any changes thereof are part of the present disclosure. Any of process layers 110, 120 may be below or above target layer 130. Any of layers 110, 120 and 130 may be applied as a positive or a negative layer. For example, target elements 135 may be gaps in a full background 132 of layer 130. In another example, target elements 135 may be segmented, i.e., constructed of segments 134 which cumulatively form target elements 135. In case target element 135 is a gap, segments 134 may be gaps. The pitches of any of the segmentation patterns may vary, particularly of segmentation patterns in different regions of each layer. For example, segmentation pitches in regions 112A and 112B may vary with respect to the direction of segmentation due to production considerations. While pitches may vary, pitches at the specified regions of target elements 135 are designed not to form Moire patterns, e.g., be identical. In certain embodiments, the parallel segmentation features of the at least two process layers have the same segmentation pitch.

[0028] In certain embodiments, at least one of the process layers may comprise, outside the specified regions, target elements which are perpendicular to features of the other process layers. For example, process layer 120 comprises in Figures 2A and 2B gap target elements 125 which may be measured with respect to process layer 110. In case background 132 of layer 130 is segmented, its segmentation features in the regions of target elements 125 are parallel to segmentation features 112A, 112B in the respective regions and thus perpendicular to target elements 125. According to such and similar embodiments, process layer 120 and target layer 130 may have alternating roles, depending on the specified regions and targets 125, 135 in each respective layer.

[0029] Figures 3A and 3B are high level schematic illustrations of a multi-layered target 100 and its layers 110, 120, 130A, 130B, 130C, respectively, according to some embodiments of the invention. Figures 3A and 3B exemplify in a non-limiting manner process layer 110 (e.g., an oxide diffusion (OD) layer) having segmentation features 112A, 112B which may differ in different regions of layer 110; process layer 120 (e.g., a polysilicon (poly) layer) having segmentation features 122A, 122B which may differ in different regions of layer 120 but are parallel to segmentation features 112A, 112B (respectively) in specified overlapping regions in which segmentation features of layers 110 and 120 are parallel to each other; and multiple target layers 130A, 130B, 130C (e.g., contact layers) having respective target elements 135A, 135B, 135C in the specified regions in which segmentation features of layers 110 and 120 are parallel to each other. Layers 110, 120, 130A, 130B, 130C are shown separately in Figure 3B and overlapping in Figure 3A. It is noted that target elements 135A, 135B, 135C are perpendicular to parallel segmentation features of layer 110, 120 in each of the target regions.

[0030] It is noted that the illustrated identities and order of layers 110, 120 and 130A, 130B, 130C is non-limiting and any changes thereof are part of the present disclosure. Any of process layers 110, 120 may be below or above any of target layers 130A, 130B, 130C. Any of layers 110, 120, 130A, 130B and 130C may be applied as a positive or a negative layer. For example, any of target elements 135A, 135B, 135C may be gaps in full backgrounds of respective layers 130A, 130B, 130C. In another example, any of target elements 135A, 135B, 135C may be segmented, i.e., constructed of respective segments 134A, 134B, 134C which cumulatively form respective target elements 135A, 135B, 135C. Segmentation directions may vary among target elements 135A, 135B, 135C - both within each target layer 130A, 130B, 130C and between target layers 130A, 130B, 130C (e.g., segmentation direction in layer 130C is perpendicular to segmentation direction in layers 130A and 130B). Locally, in the specified regions, the orientation of any or target elements 135A, 135B and 135C is perpendicular to the local parallel segmentation features of layers 110, 120. In case any of target elements 135A, 135B, 135C is a gap, respective segments 134A, 134B, 134C may be gaps. The pitches of any of the segmentation patterns may vary, particularly of segmentation patterns in different regions of each layer. For example, segmentation pitches in regions 112A and 112B may vary with respect to the direction of segmentation due to production considerations. While pitches may vary, pitches at the specified regions of any of target elements 135A, 135B, 135C are designed not to form Moire patterns, e.g., be identical. In certain embodiments, the parallel segmentation features of the at least two process layers have the same segmentation pitch.

[0031] In certain embodiments, at least one of the process layers may comprise, outside the specified regions, target elements which are perpendicular to features of the other process layers. For example, both process layer 120 comprises in Figures 3A and 3B target elements 125 which may be measured with respect to process layer 110; and process layer 110 comprises in Figures 3A and 3B target elements 115 which may be measured with respect to process layer 120. In case the background in any of layers 130A, 130B, 130C is segmented, its segmentation features in the regions of target elements 115 and/or 125 are parallel to segmentation features 122A, 122B and/or 112A, 112B in the respective regions and thus perpendicular to target elements 115, 125 respectively. According to such and similar embodiments, process layer 120 and/or 110 and any respective target layer 130A, 130B, 130C may have alternating roles, depending on the specified regions and targets 115, 125, 135A, 135B, 135C in each respective layer.

[0032] Figures 4A and 4B are high level schematic illustrations of a multi-layered target 100 and its layers 110, 120, respectively, according to some embodiments of the invention. Figures 4A and 4B exemplify in a non-limiting manner process layer 110 (e.g., an oxide diffusion (OD) layer) having segmentation features 112A, 112B which may differ in orientation and segmentation parameters (e.g., pitch, feature width) in different regions of layer 110; and process layer 120 (e.g., a polysilicon (poly) layer) having segmentation features 122A, 122B which may differ in orientation and segmentation parameters (e.g., pitch, feature width) in different regions of layer 120 but are parallel to segmentation features 112A, 112B (respectively) in specified overlapping regions in which segmentation features of layers 110 and 120 are parallel to each other.

[0033] and target layer 130 (e.g., a contact layer) having target elements 135 in the specified regions in which segmentation features of layers 110 and 120 are parallel to each other. Layers 110, 120 are shown separately in Figure 4B and overlapping in Figure 4A.

[0034] . In certain embodiments, either or both layers 110, 120 may comprise features 114, 124 respectively which may be used as target elements 115, 125 with respect to the other layer 120, 110, respectively. It is noted that target elements 115, 125 are perpendicular to parallel segmentation features of layer 120, 110, respectively in each of the specified regions. Generally, at least one of the process layers may comprise, outside the specified regions, target elements which are perpendicular to features of the other process layers. For example, process layers 110, 120 comprise in Figures 4A and 4B gaps 114, 124 as target elements 115, 125 which may be measured with respect to process layers 120, 110 respectively.

[0035] It is noted that the illustrated identities and order of layers 110 and 120 is non-limiting and any changes thereof are part of the present disclosure. Process layers 110, 120 may be switched or multiple layers may be combined into targets 100 according to the disclosed principles. Any of layers 110, 120 may be applied as a positive or a negative layer. Any of target elements 115, 125 may be gaps in a full or segmented background, be full elements or be segmented, i.e., constructed of segments as illustrated in Figure IB. The pitches of any of the segmentation patterns may vary, particularly of segmentation patterns in different regions of each layer. For example, segmentation pitches in regions 112A, 112B and 122A, 122B, respectively, may vary with respect to the direction of segmentation due to production considerations. While pitches may vary, pitches at the specified regions of target elements 115, 125 are designed not to form Moire patterns, e.g., be identical to their background segmentation in the specified regions. In certain embodiments, the parallel segmentation features of the at least two process layers have the same segmentation pitch.

[0036] In any of the embodiments, parallel segmentation features at some of the specified regions may be configured to be perpendicular to the parallel segmentation features at other specified regions. Any of targets 100 may be configured to have a rotational symmetry of 180°, 120°, 90°, 60°, 45° and/or 30°.

[0037] Figure 5 is a high level flowchart illustrating a method 200, according to some embodiments of the invention. Method 200 may comprise stages for designing and or producing targets 100, such as any of the following stages, irrespective of their order. Any of the designing and the configuring stages may be carried out by at least one computer processor. Certain embodiments comprise computer program products comprising a computer readable storage medium having computer readable program embodied therewith. The computer readable program may be configured to carry out stages of method 200. Also provided are design files which are produced according to stages of method 200. Certain embodiments comprise a computer program product comprising a computer readable storage medium having computer readable program embodied therewith. The computer readable program may be configured to carry out metrology measurements of targets 100 or any targets produced according to method 200.

[0038] Method 200 may comprise designing at least two process layers of a multi-layered target to have parallel segmentation features at specified regions (stage 210) and/or producing the process layers to have parallel segmentation features at specified regions (stage 215), and configuring target elements of at least one target layer of the multi-layered target to be perpendicular to the parallel segmentation features of the process layers at the specified regions (stage 220). Method 200 may further comprise producing the target elements to be perpendicular to the parallel segmentation features of the process layers at the specified regions (stage 225).

[0039] Method 200 may further comprise configuring the parallel segmentation features of the process layers to have the same pitch or at least not to form Moire pattern(s) (stage 230) and/or designing the parallel segmentation features at some of the specified regions to be perpendicular to the parallel segmentation features at other specified regions (stage 240).

[0040] Method 200 may further comprise configuring target elements at process layer(s) outside the specified regions, which are perpendicular to the features of other process layers (stage 245) and/or designing distinct specified regions for target elements in different target layers (stage 280).

[0041] Method 200 may further comprise any of the following stages: configuring the target elements as full bars, gap bars and/or segmented bars (parallel or perpendicular to the parallel segmentation features) (stage 260); configuring a periphery of the target elements to be full, empty or segmented (stage 270); configuring the multi-layered target to have a rotational symmetry of any of 180°, 120°, 90°, 60°, 45° and 30° (stage 285).

[0042] Method 200 may further comprise carrying out the designing and/or the configuring by at least one computer processor (stage 290), as well as producing and/or providing target design files and/or metrology target. Method 200 may further comprise carrying out the respective metrology measurements of the disclosed targets as well.

[0043] Advantageously, disclosed multi-layered targets overcome several shortcomings of prior art targets, including for example process damage to the target itself and lack of compatibility of the target with semiconductor manufacturing design rules. Specific shortcomings include (i) violation of design rules for specific layers where orthogonal dummification (i.e., addition of dummyfill) is not allowed such as contacts to isolation which are not allowed on poly; (ii) dishing within or in the vicinity of the target due to chemical mechanical polishing; (iii) etch bias in the vicinity of the target due to incompatible pattern density; (iv) subsequent parasitic capacitance in the device due to design rule violation in the target; (v) lithographic incompatibility of the target causing metrology bias in the metrology result; and (vi) increase in metrology footprint on reticle and wafer due to excessive target size. Specifically, the present invention discloses improved methods for applying dummyfill to a target design and resulting targets.

[0044] Advantageously, disclosed multi-layered targets reveal and optimize specific dummyfill patterns and filling considerations which enable or enhance metrology measurements while conforming to design rules and thus producing accurate targets. As adding dummyfill to multi-layered target may quickly deteriorate the metrology measurement quality, the disclosed principles allow designing and producing viable metrology targets which nevertheless comprise dummyfill in form of the disclosed segmentation patterns.

[0045] 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.

[0046] 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.

[0047] 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 used in the specific embodiment alone.

[0048] 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.

[0049] 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.

[0050] 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.

[0051] 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 multi-layered target comprising:

   at least two process layers arranged to have parallel segmentation features at specified regions, and

   at least one target layer comprising target elements which are perpendicular to the parallel segmentation features of the process layers at the specified regions.

2. The multi-layered target of claim 1, wherein the target elements are any of: full bars, gap bars, bars segmented in parallel to the parallel segmentation features of the process layers at the specified regions and bars segmented perpendicularly to the parallel segmentation features of the process layers at the specified regions.
3. The multi-layered target of claim 1, wherein the target elements are bars segmented in parallel to the parallel segmentation features of the process layers at the specified regions, and wherein the bar segmentation is configured to create a Moire pattern with the parallel segmentation features that is configured to facilitate ROI placement or target acquisition.
4. The multi-layered target of claim 1, wherein a periphery of the target elements at the at least one target layer is full, empty or segmented.
5. The multi-layered target of claim 1, wherein at least one of the process layers comprises, outside the specified regions, target elements which are perpendicular to features of the other process layers.
6. The multi-layered target of claim 1, wherein the parallel segmentation features of the at least two process layers have the same segmentation pitch.
7. The multi-layered target of claim 1, wherein the parallel segmentation features of the at least two process layers are configured to have segmentation pitches which do not form a Moire pattern between the process layers.
8. The multi-layered target of claim 1, wherein the at least one target layer comprises a plurality of target layers, each having target elements at distinct specified regions.
9. The multi-layered target of claim 1, configured to have a rotational symmetry of at least one of: 180°, 120°, 90°, 60° and 30°.

10. The multi-layered target of claim 1, wherein the parallel segmentation features at some of the specified regions are perpendicular to the parallel segmentation features at other specified regions.

11. A method comprising:

designing at least two process layers of a multi-layered target to have parallel segmentation features at specified regions, and

configuring target elements of at least one target layer of the multi-layered target to be perpendicular to the parallel segmentation features of the process layers at the specified regions,

wherein at least one of: the designing and the configuring is carried out by at least one computer processor.

12. A method comprising producing at least two process layers of a multi-layered target to have parallel segmentation features at specified regions, and at least one target layer of the multi-layered target to have target elements which are perpendicular to the parallel segmentation features of the process layers at the specified regions.

13. The method of claim 11 or 12, further comprising configuring the target elements as any of: full bars, gap bars, bars segmented in parallel to the parallel segmentation features of the process layers at the specified regions and bars segmented perpendicularly to the parallel segmentation features of the process layers at the specified regions.

14. The method of claim 11 or 12, further comprising designing the target elements as bars which are segmented in parallel to the parallel segmentation features of the layers at the specified regions, and configuring the bar segmentation to create a Moire pattern with the parallel segmentation features that is configured to facilitate ROI placement or target acquisition.

15. The method of claim 11 or 12, further comprising configuring a periphery of the target elements at the at least one target layer to be full, empty or segmented.

16. The method of claim 11 or 12, further comprising configuring at least one of the process layers to comprise, outside the specified regions, target elements which are perpendicular to features of the other process layers.

17. The method of claim 11 or 12, further comprising configuring the parallel segmentation features of the at least two process layers to have the same segmentation pitch.
18. The method of claim 11 or 12, further comprising configuring the parallel segmentation features of the at least two process layers to have segmentation pitches which do not form a Moire pattern between the process layers.
19. The method of claim 11 or 12, further comprising configuring distinct specified regions for target elements in a plurality of target layers.
20. The method of claim 11 or 12, further comprising configuring the multi-layered target to have a rotational symmetry of at least one of: 180°, 120°, 90°, 60°, 45° and 30°.
21. The method of claim 11 or 12, further comprising configuring the parallel segmentation features at some of the specified regions are perpendicular to the parallel segmentation features at other specified regions.
22. The method of any one of claims 11-21, further comprising at least one of: producing respective target design files of the multi-layered, producing respective multi-layered targets and performing metrology measurements of the respective multi-layered targets.
23. A computer program product comprising a computer readable storage medium having computer readable program embodied therewith, the computer readable program configured to carry out the method of any one of claims 11-22.
24. A target design file, designed or produced according to the method of any one of claims 11-21.
25. A multi-layer target designed, produced or measured according to the method of any one of claims 11-21.

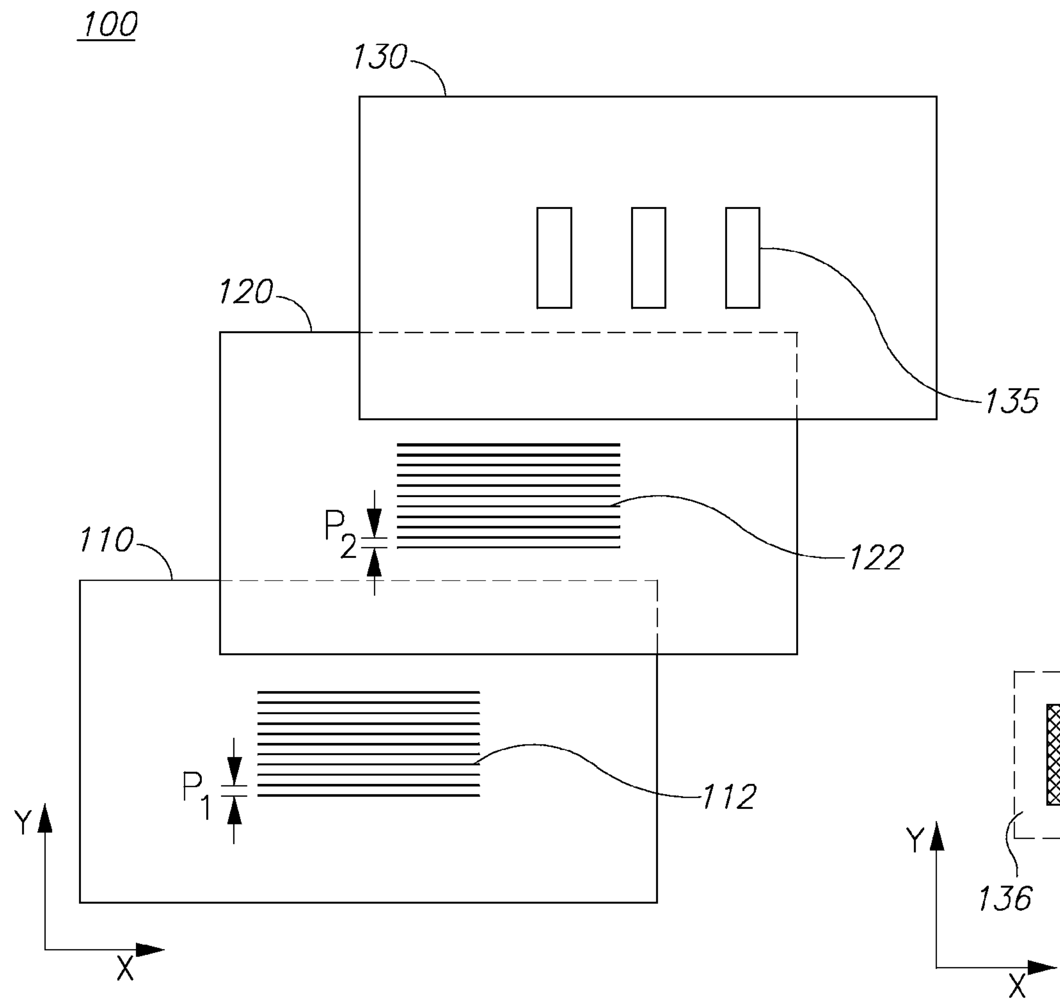


Figure 1A

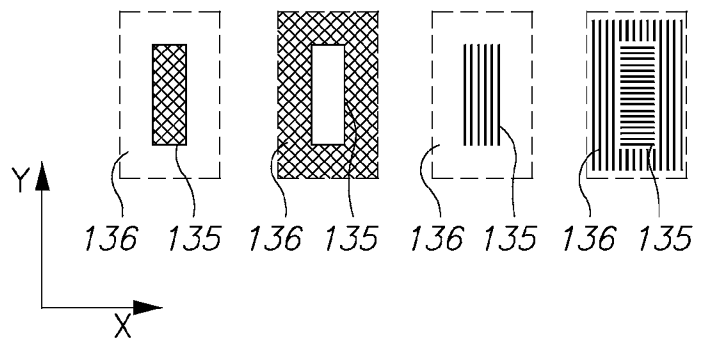
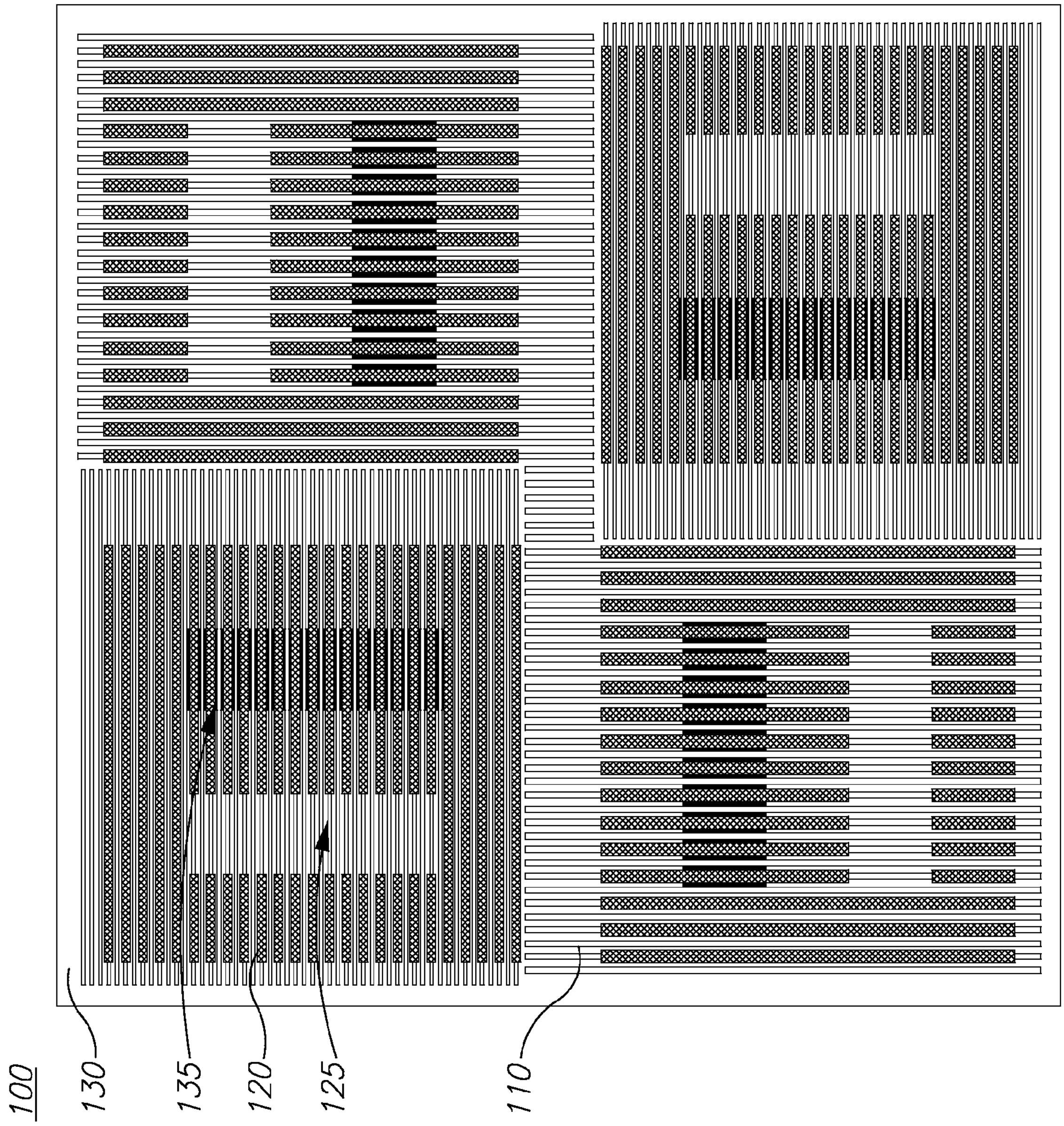


Figure 1B

Figure 2A



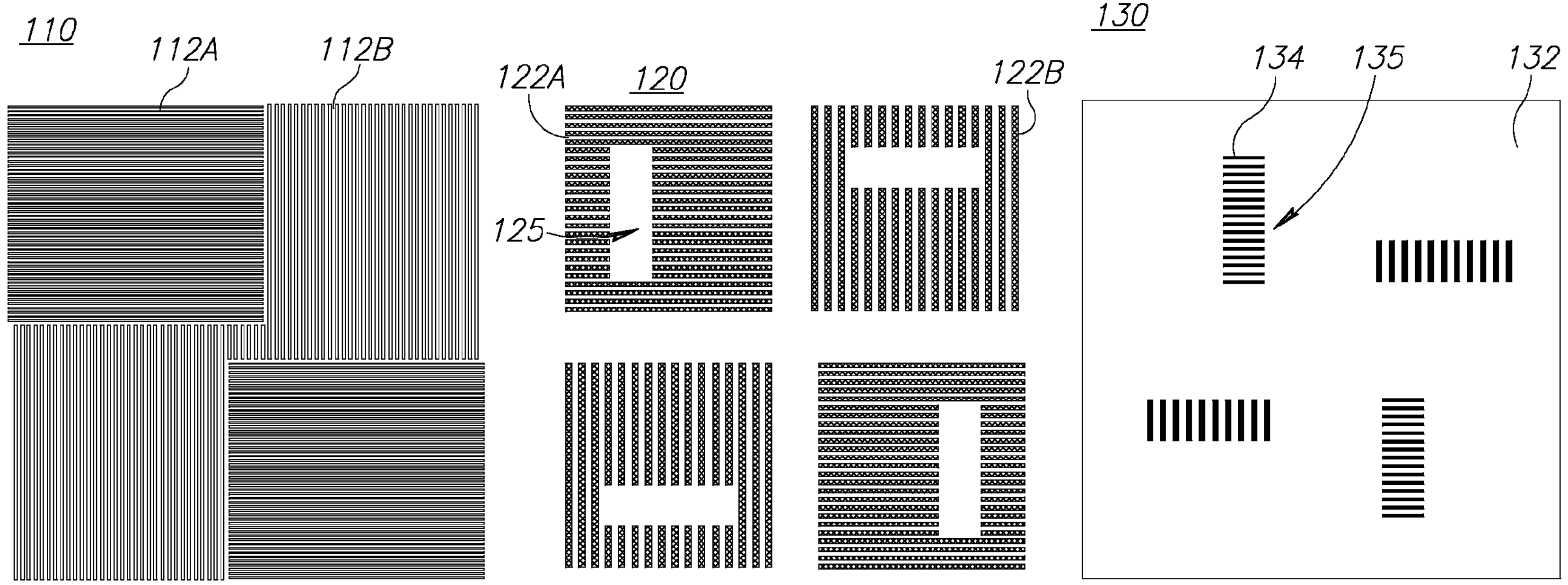


Figure 2B

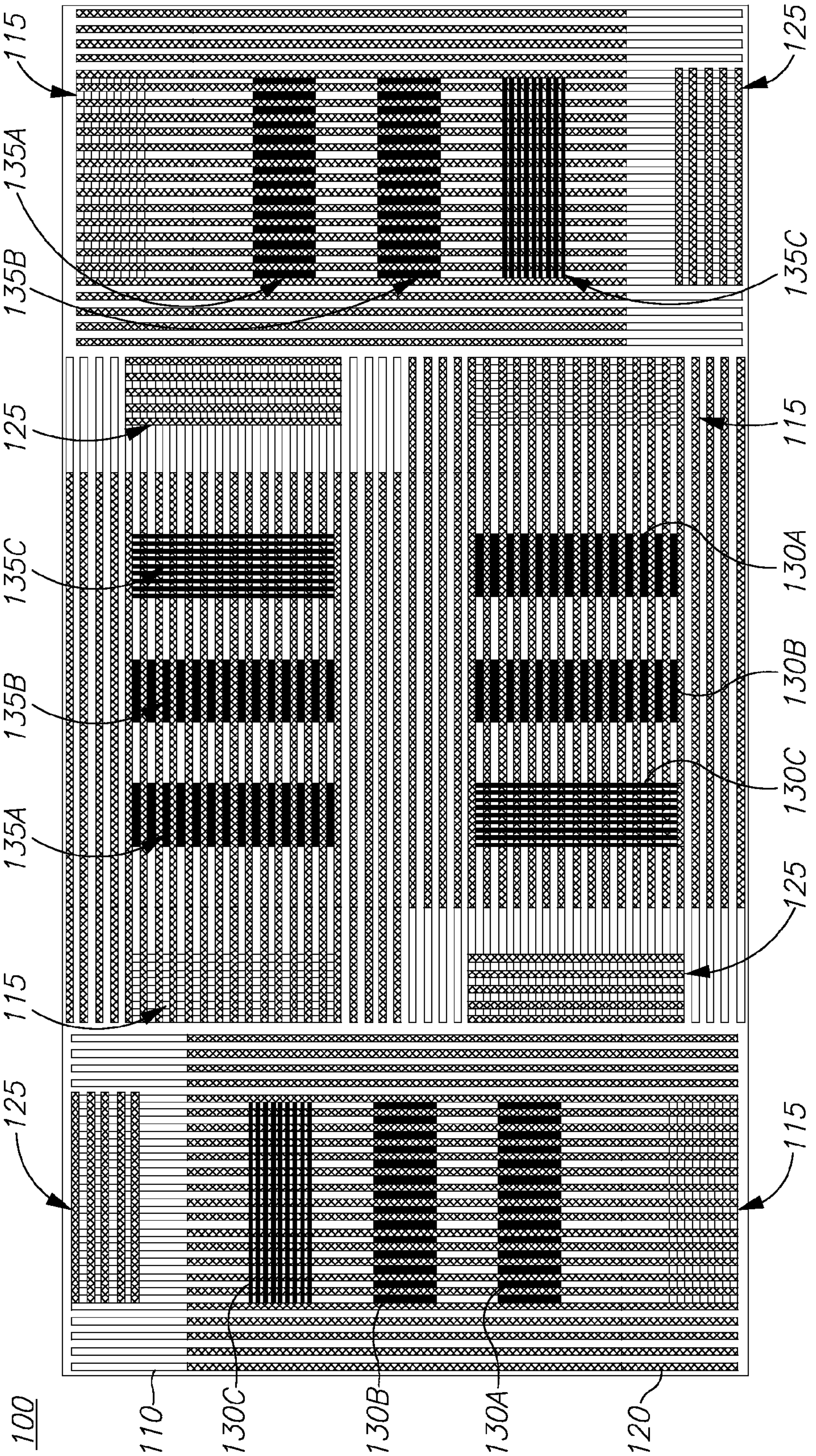

115
135A
135B
125
135C
135B
135A
115
125
100
110
130C
130B
130A
120
125
135C
115
130A
130B
130C
125
115

Figure 3A


130A
134A
135A
130B
134B
135B
130C
134C
135C
110
112A
112B
112C
115
120
122A
122B
122C
125

Figure 3B

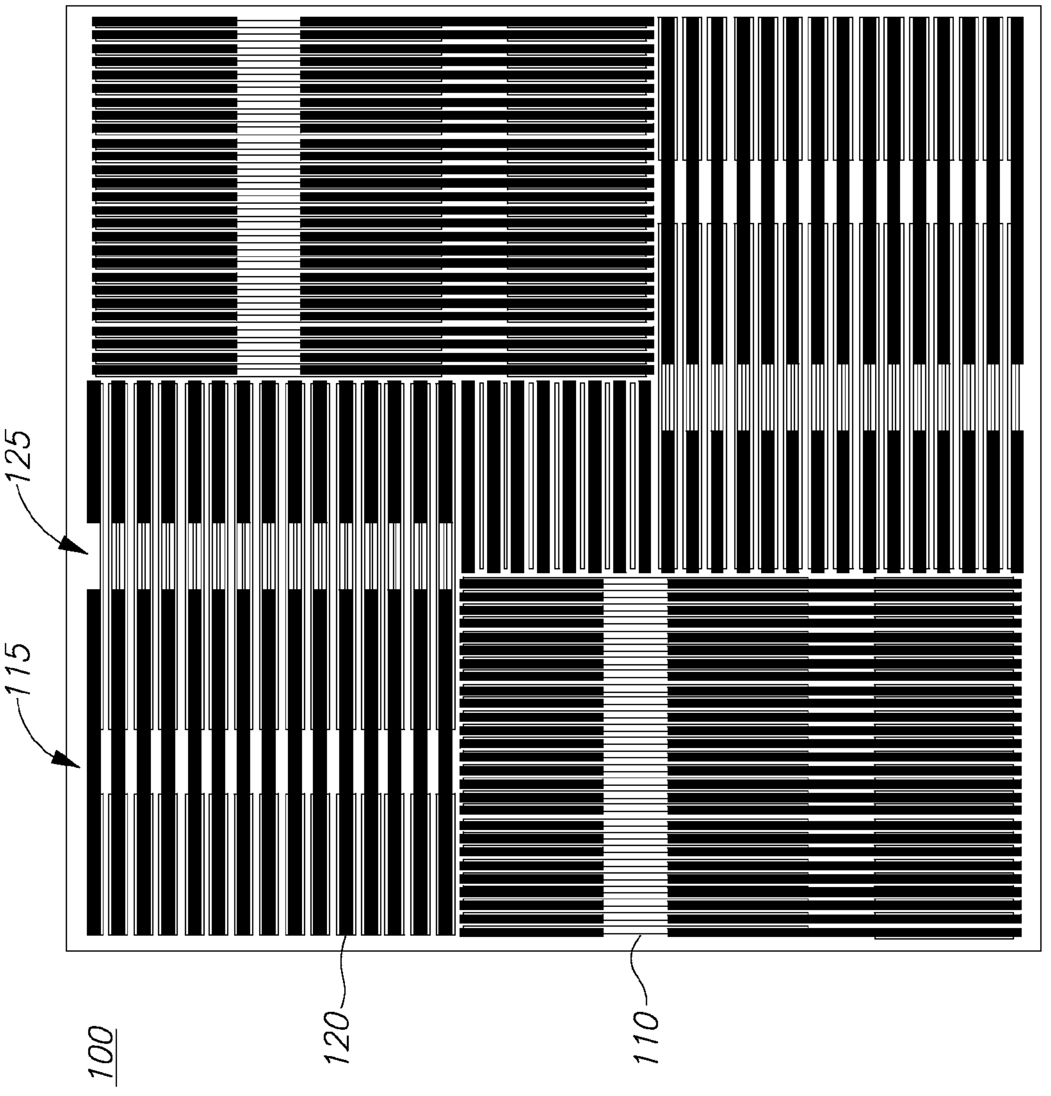


Figure 4A

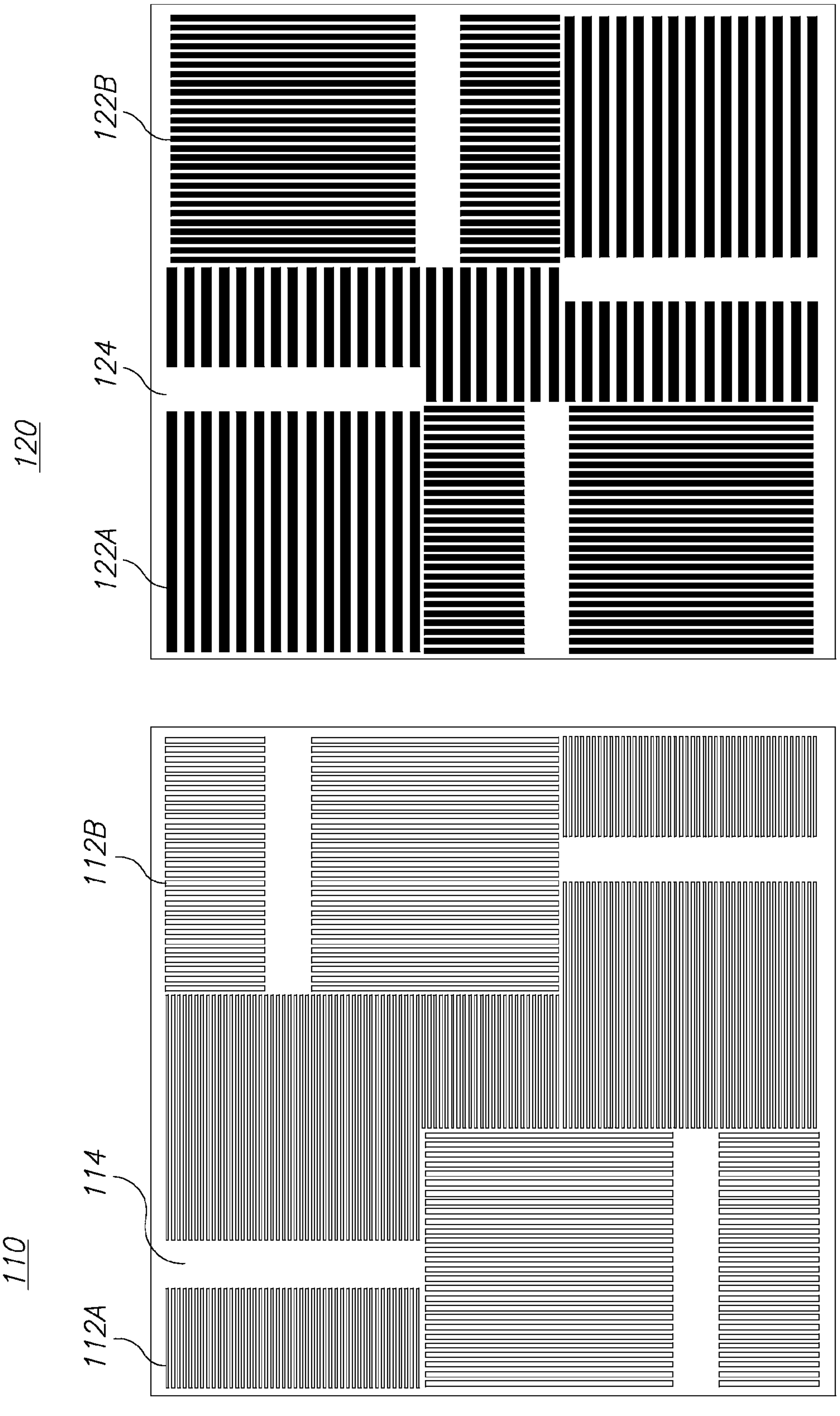


Figure 4B

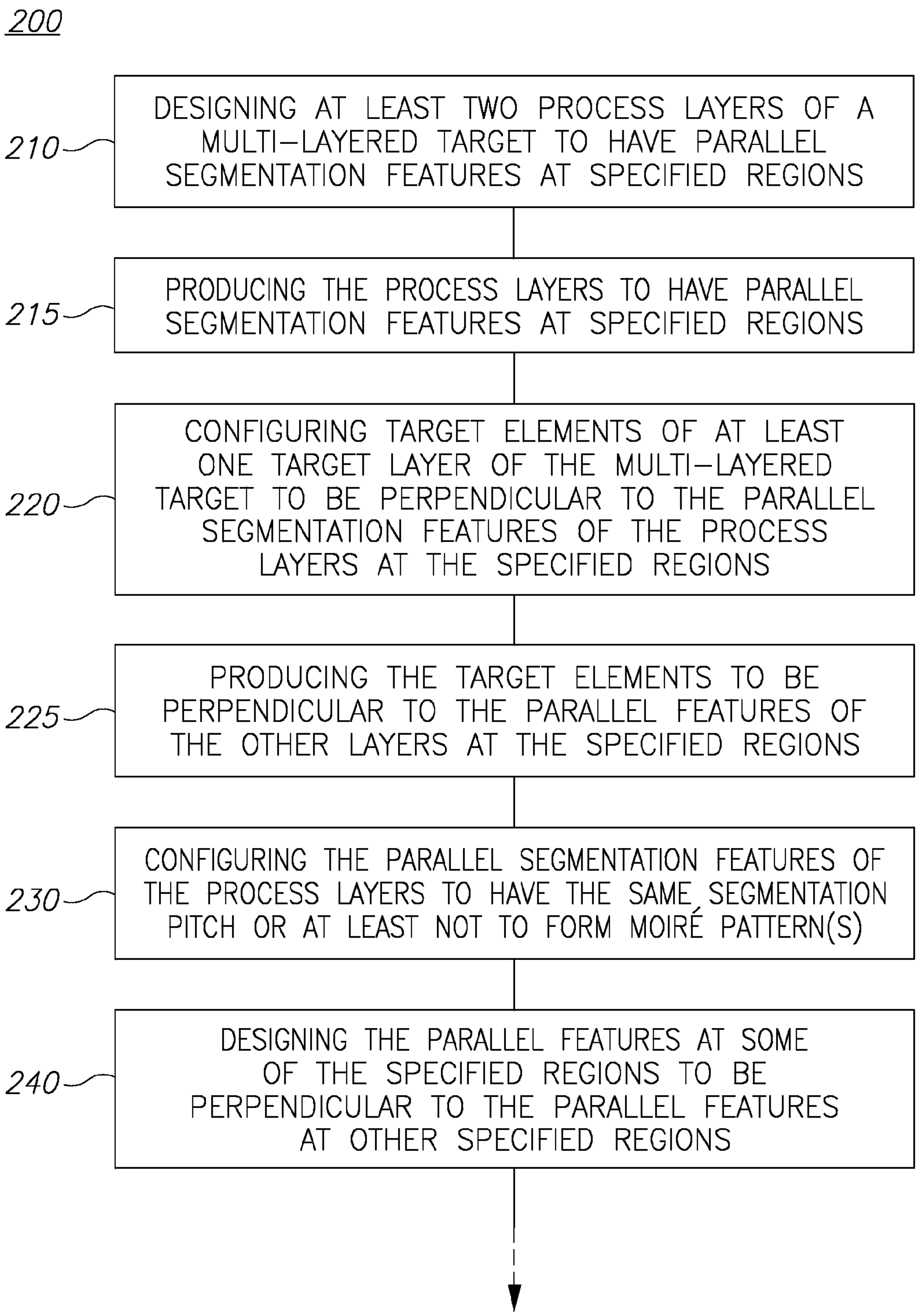

200
210
DESIGNING AT LEAST TWO PROCESS LAYERS OF A MULTI–LAYERED TARGET TO HAVE PARALLEL SEGMENTATION FEATURES AT SPECIFIED REGIONS
215
PRODUCING THE PROCESS LAYERS TO HAVE PARALLEL SEGMENTATION FEATURES AT SPECIFIED REGIONS
220
CONFIGURING TARGET ELEMENTS OF AT LEAST ONE TARGET LAYER OF THE MULTI–LAYERED TARGET TO BE PERPENDICULAR TO THE PARALLEL SEGMENTATION FEATURES OF THE PROCESS LAYERS AT THE SPECIFIED REGIONS
225
PRODUCING THE TARGET ELEMENTS TO BE PERPENDICULAR TO THE PARALLEL FEATURES OF THE OTHER LAYERS AT THE SPECIFIED REGIONS
230
CONFIGURING THE PARALLEL SEGMENTATION FEATURES OF THE PROCESS LAYERS TO HAVE THE SAME SEGMENTATION PITCH OR AT LEAST NOT TO FORM MOIRÉ PATTERN(S)
240
DESIGNING THE PARALLEL FEATURES AT SOME OF THE SPECIFIED REGIONS TO BE PERPENDICULAR TO THE PARALLEL FEATURES AT OTHER SPECIFIED REGIONS

Figure 5

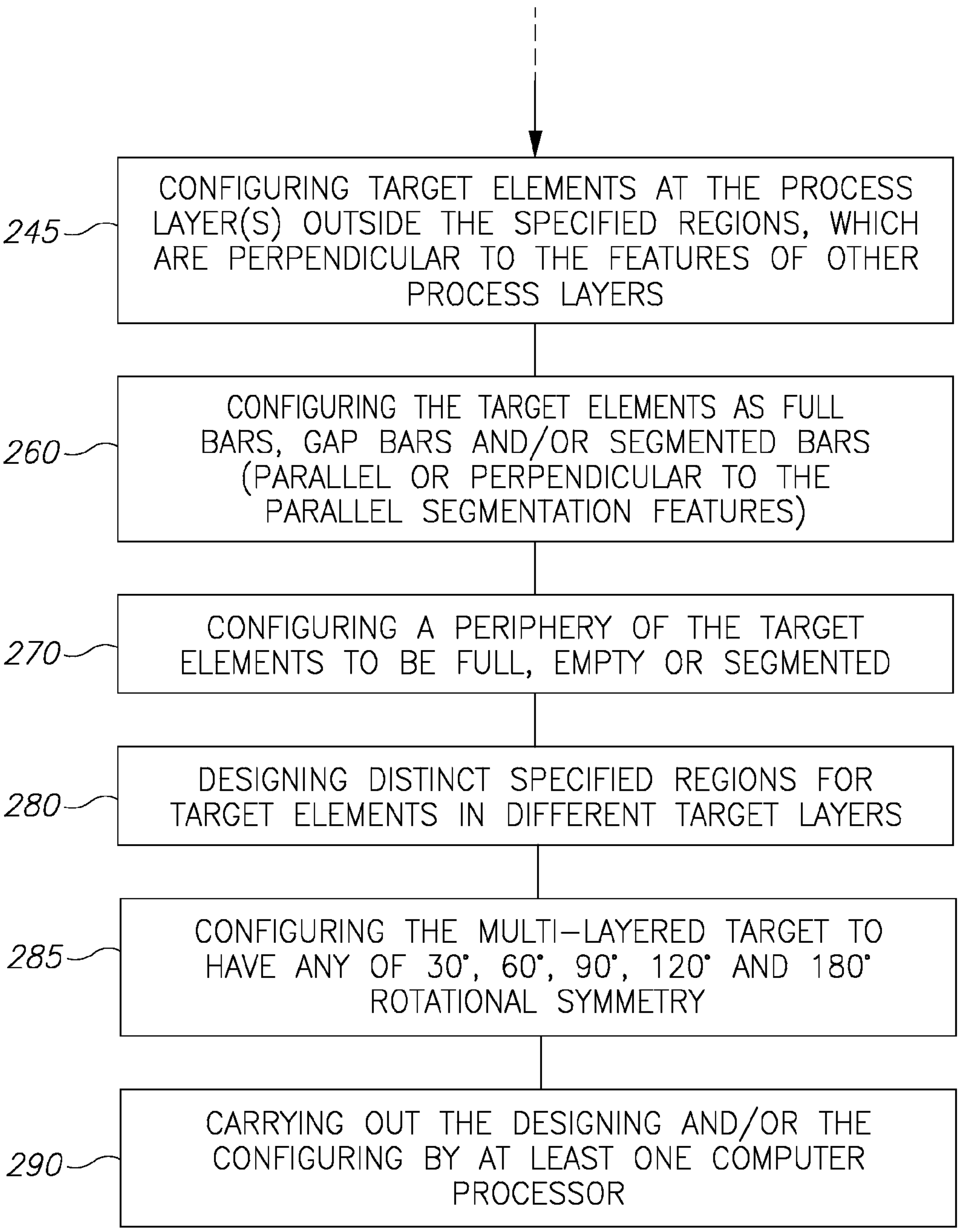


Figure 5 (cont. 1)

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 22-25
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required addtional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of any additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest
☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/039833

A. CLASSIFICATION OF SUBJECT MATTER

H01L 21/66(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01L 21/66; G06F 17/50; G01J 4/00; G01B 11/06; H01L 23/544; G01B 11/00; G03F 7/20

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: multi-layer, overlay, wafer, perpendicular, and similar terms.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2012-0033215 Al (DANIEL KANDEL et al.) 09 February 2012 See paragraphs [0033H0034], [0043H0047], [0050H0055], [0070H0071], [0073], [0100], claim 1, and figures 3-5, 8-10.	1-21
A	US 2013-0107259 Al (DONGSUB CHOI et al.) 02 May 2013 See paragraphs [0040]- [0048]; claim V, and figure 2.	1-21
A	US 2005-0193362 Al (KHOI A. PHAN et al.) 01 September 2005 See paragraphs [0050]- [0053]; claim V, and figure 9.	1-21
A	US 2011-0069314 Al (CHRISTOPHER P.AUSSCHNITT et al.) 24 March 2011 See paragraphs [0044]- [0047] and figure 3.	1-21
A	US 2011-0248388 Al (CHRISTOPHER P.AUSSCHNITT et al.) 13 October 2011 See paragraphs [0022]- [0026] and claim 1.	1-21

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search
26 September 2014 (26.09.2014)

Date of mailing of the international search report
26 September 2014 (26.09.2014)

Name and mailing address of the ISA/KR
International Application Division
Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701,
Republic of Korea
Facsimile No. +82-42-472-7140

Authorized officer
KΓM, Young Jin
Telephone No. +042 481 5771

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/039833

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2012-0033215 Al	09/02/2012	CN 103038861 A	10/04/2013
		EP 2601675 A2	12/06/2013
		JP 2013-534314 A	02/09/2013
		KR 10-1380532 Bl	01/04/2014
		KR 10-2013-0088848 A	08/08/2013
		KR 10-2013-0090421 A	13/08/2013
		TW 1429038 B	01/03/2014
		WO 2012-018673 A2	09/02/2012
		WO 2012-018673 A3	18/05/2012
US 2013-0107259 Al	02/05/2013	KR 10-2014-0096331 A	05/08/2014
		TW 201324061 A	16/06/2013
		WO 2013-067064 Al	10/05/2013
US 2005-0193362 Al	01/09/2005	CN 1926677 A	07/03/2007
		GB 2427268 A	20/12/2006
		GB 2427268 B	02/01/2008
		JP 2007-528126 A	04/10/2007
		KR 10-1187061 Bl	28/09/2012
		KR 10-2006-0129421 A	15/12/2006
		TW 1375251 B	21/10/2012
		US 7065737 B2	20/06/2006
		WO 2005-086223 A2	15/09/2005
		WO 2005-086223 A3	08/09/2006
US 2011-0069314 Al	24/03/2011	US 2007-0058169 Al	15/03/2007
		US 2008-0259334 Al	23/10/2008
		US 2011-0058170 Al	10/03/2011
		US 7474401 B2	06/01/2009
		US 7876439 B2	25/01/2011
		US 8107079 B2	31/01/2012
		US 8339605 B2	25/12/2012
US 2011-0248388 Al	13/10/2011	US 2013-075871 Al	28/03/2013
		US 8361683 B2	29/01/2013