

TITLE OF INVENTION: INFORMATION PROCESSING METHOD AND INFORMATION PROCESSING APPARATUS

BACKGROUND

5 [0001]

The present disclosure relates to an information processing method and an information processing apparatus.

[0002]

Japanese Unexamined Patent Application Publication No. 2020-085839
10 describes a technique for detecting a defect present in a sample.

SUMMARY

[0003]

Accurately managing the position of a specific point in a sample is desired.

15 [0004]

The present disclosure, which has been made to solve such a problem, is to provide an information processing method and an information processing apparatus that can manage the position of a specific point with high accuracy.

[0005]

20 An information processing method of the present disclosure includes:
an acquisition step of acquiring coordinates of alignment marks of a plurality of sections of a sample for calibration having regions sectioned by four alignment marks; and

a recording step of calculating, for each of the plurality of sections, a
25 coefficient for performing coordinate transformation of a region contained in the section into a coordinate system based on the coordinates of the alignment marks of the section, and recording the coefficient in association with the section.

[0006]

The information processing method of the present disclosure may further
30 include:

a determination step of determining to which section among the plurality of sections in the sample for calibration a specific point in an inspection sample belongs;

a reading step of reading the coefficient associated with the section to

which the specific point is determined to belong; and

a transformation step of transforming coordinates of the specific point based on the coefficient.

[0007]

5 The information processing method of the present disclosure, in which in the acquisition step, coordinates of the alignment marks of the section may be further acquired by correcting the coordinates using a function based on an elapsed time.

[0008]

10 The information processing method of the present disclosure, in which in the acquisition step, coordinates of adjacent columns of the alignment marks of the section may be further scanned and measured in the same direction.

[0009]

15 The information processing method of the present disclosure may further include a second transformation step of transforming the transformed coordinates obtained in the transformation step, based on global alignment marks of the inspection sample.

[0010]

20 The information processing method of the present disclosure, in which the coordinate transformation may be the Helmert transformation, an affine transformation, or a homography transformation.

[0011]

25 An information processing apparatus of the present disclosure includes: an acquisition unit that acquires coordinates of alignment marks of a plurality of sections of a sample for calibration having regions sectioned by four alignment marks; and

30 a recording unit that calculates, for each of the plurality of sections, a coefficient for performing coordinate transformation of a region contained in the section into a coordinate system based on the coordinates of the alignment marks of the section, and records the coefficient in association with the section.

[0012]

The information processing apparatus of the present disclosure may further include:

a determination unit that determines to which section among the plurality of

sections in the sample for calibration a specific point in an inspection sample belongs;

a reading unit that reads the coefficient associated with the section to which the specific point is determined to belong; and

5 a transformation unit that transforms coordinates of the specific point based on the coefficient.

[0013]

The information processing apparatus of the present disclosure, in which in the acquisition unit, coordinates of the alignment marks of the section may be
10 further acquired by correcting the coordinates using a function based on an elapsed time.

[0014]

The information processing apparatus of the present disclosure, in which in the acquisition unit, coordinates of adjacent columns of the alignment marks of
15 the section may be further scanned and measured in the same direction.

[0015]

The information processing apparatus of the present disclosure may further include a second transformation unit that transforms the transformed coordinates obtained by the transformation unit, based on global alignment marks of the
20 inspection sample.

[0016]

The information processing apparatus of the present disclosure, in which the coordinate transformation may be the Helmert transformation, an affine transformation, or a homography transformation.

25 [0017]

According to the present disclosure, it is possible to provide an information processing method and an information processing apparatus that can manage the position of a specific point with high accuracy.

The above and other objects, features and advantages of the present
30 disclosure will become more fully understood from the detailed description given hereinbelow and the accompanying drawings.

BRIEF DESCRIPTIONS OF DRAWINGS

[0018]

Fig. 1 is a block diagram showing a configuration of an information processing apparatus according to an embodiment;

Fig. 2 is a flowchart of an information processing method according to the embodiment;

5 Fig. 3 is a schematic diagram showing alignment mark coordinates according to the embodiment;

Fig. 4 is a schematic diagram showing deviation of the alignment mark coordinates according to the embodiment;

10 Fig. 5 is a schematic diagram showing the position of a specific point corresponding to alignment mark coordinates according to Embodiment 1;

Fig. 6 is a schematic diagram of the alignment mark coordinates and the specific point before and after calibration according to Embodiment 1, and is a schematic diagram of global alignment mark coordinates;

15 Fig. 7 is a schematic diagram of measurement of the alignment mark coordinates after time has passed according to Embodiment 1;

Fig. 8 is a schematic diagram showing an example of unidirectional measurement and meandering measurement of the alignment mark coordinates according to Embodiment 1; and

20 Fig. 9 is a block diagram showing a physical configuration of the information processing apparatus according to the embodiment.

DESCRIPTION OF EMBODIMENTS

[0019]

<Embodiments>

25 Hereinafter, embodiments according to the present disclosure will be described with reference to the drawings. However, the disclosure according to the scope of the claims is not limited to the following embodiments.

Furthermore, not all of the configurations described in the embodiments are essential as means for solving the problem. For clarity of explanation, the following description and drawings are omitted and simplified as appropriate. In
30 the drawings, the same elements are denoted by the same reference numerals and redundant description is omitted as necessary.

[0020]

(Description of Information Processing Apparatus and Information

Processing Method According to Embodiment)

Fig. 1 is a block diagram showing a configuration of an information processing apparatus according to an embodiment. Fig. 2 is a flowchart of an information processing method according to the embodiment. Fig. 3 is a schematic diagram showing alignment mark coordinates according to the embodiment. Fig. 4 is a schematic diagram showing deviation of the alignment mark coordinates according to the embodiment. Fig. 9 is a block diagram showing a physical configuration of the information processing apparatus according to the embodiment. The information processing apparatus and the information processing method according to the embodiment will be described with reference to Fig. 1 to Fig. 4 and Fig. 9. The information processing apparatus according to the embodiment is used for, for example, identifying a defect in a mask.

[0021]

In EUV lithography, a method is used for disposing an absorber directly above a transferable phase defect. In the above method, defect coordinates are recognized with reference to marks present at four corners of the mask, phase defect coordinates are recognized, and the phase defect coordinates and the absorber are aligned down to the nanometer.

[0022]

For example, accurately managing the position of the defect is desired in the following situations. That is, a situation is assumed where coordinate positions recorded as the position at which a defect is detected may differ slightly even for the same sample, due to differences between inspection apparatuses or the like. Another situation is assumed where if a process is performed of a first apparatus detecting a defect and a second apparatus repairing or disabling the defect, the position on a sample where the defect is detected may be slightly different in the first apparatus than the position on the sample where the defect is supposed to be in the second apparatus, due to a difference between the two apparatuses.

[0023]

Accordingly, an apparatus and a method are proposed for identifying and managing the position of the defect, in order to mitigate the effect of the differences between the inspection apparatuses that detect the defect and between

the defect inspection apparatus and apparatuses in subsequent processes.
[0024]

As shown in Fig. 3, in the mask, coordinates referred to as alignment marks are provided in a grid in which a plurality of vertical columns and horizontal rows are aligned. Here, the alignment marks are, for example, plus marks numbered from 1 to 225. The alignment marks are also referred to as fiducial marks (FM). As shown in the bottom right portion of Fig. 3, measurement errors distributed within a mask surface are varied, even if only FM coordinates at the four corners at the outermost portions of the mask are used for correction.

[0025]

As shown in Fig. 4, a stretching direction within the surface differs depending on a cell of each alignment mark. For example, the top left-most cell is stretched in a top left direction. As shown in the right diagram of Fig. 4, upon enlarging this top left cell, it can be understood that a specific portion, such as a defect at the position of the black triangle in the black pre-calibrated cell, is detected at the position of the white triangle upon being aligned with the white calibrated cell. It is possible to detect the position of the specific portion regardless of the difference between apparatuses, by performing transformation based on four alignment marks in a cell region to which the specific point belongs.

[0026]

As shown in Fig. 1, an information processing apparatus 100 includes an acquisition unit 101 and a recording unit 102. As shown in Fig. 9 as a physical configuration, the information processing apparatus 100 includes a memory 902 that stores a program and a processor 901 that executes processing based on the stored program. The information processing apparatus 100 may consist of one apparatus or may consist of a plurality of apparatuses. The information processing apparatus 100 may comprise a cloud server that processes some or all functions in a distributed manner.

[0027]

The acquisition unit 101 acquires coordinates of alignment marks of a plurality of sections of a sample for calibration having regions sectioned by four alignment marks. The recording unit 102 calculates, for each section, a coefficient for performing coordinate transformation of a region contained in a

section into a coordinate system based on coordinates of alignment marks of the section, and records the coefficient in association with the section. The recording unit 102 calculates and records the coefficient for transforming each section to a corrected cell.

5 [0028]

The coordinate transformation may be the Helmert transformation using two points of a cell, an affine transformation using three points, or a homography transformation referred to as projective transformation using four points. Since four cell points are measured, homography transformation can be preferable because it has fewer errors.

10

[0029]

Homography transformation can be represented by a homogeneous transformation such as:

[Formula 1]

$$x' = Hx \Leftrightarrow \begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = H \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

15

where x' is the point after the transformation and x is the point before the transformation.

Here, a homography transformation matrix H is represented by:

[Formula 2]

$$H = \begin{bmatrix} h_{00} & h_{01} & h_{02} \\ h_{10} & h_{11} & h_{12} \\ h_{20} & h_{21} & 1 \end{bmatrix}$$

20

In a case where cell points $x_0, y_0, \dots, y'_3$ are known, the homography transformation matrix H is obtained by solving simultaneous equations derived from:

[Formula 3]

$$\begin{bmatrix} x'_0 \\ y'_0 \\ x'_1 \\ y'_1 \\ x'_2 \\ y'_2 \\ x'_3 \\ y'_3 \end{bmatrix} = \begin{bmatrix} x_0 & y_0 & 1 & 0 & 0 & 0 & -x_0x'_0 & -y_0x'_0 \\ 0 & 0 & 0 & x_0 & y_0 & 1 & -x_0y'_0 & -y_0y'_0 \\ x_1 & y_1 & 1 & 0 & 0 & 0 & -x_1x'_1 & -y_1x'_1 \\ 0 & 0 & 0 & x_1 & y_1 & 1 & -x_1y'_1 & -y_1y'_1 \\ x_2 & y_2 & 1 & 0 & 0 & 0 & -x_2x'_2 & -y_2x'_2 \\ 0 & 0 & 0 & x_2 & y_2 & 1 & -x_2y'_2 & -y_2y'_2 \\ x_3 & y_3 & 1 & 0 & 0 & 0 & -x_3x'_3 & -y_3x'_3 \\ 0 & 0 & 0 & x_3 & y_3 & 1 & -x_3y'_3 & -y_3y'_3 \end{bmatrix} \begin{bmatrix} h_{00} \\ h_{01} \\ h_{02} \\ h_{10} \\ h_{11} \\ h_{12} \\ h_{20} \\ h_{21} \end{bmatrix}$$

25

[0030]

According to the above configuration, the information processing apparatus

is provided that can manage the position of the specific point with high accuracy.
[0031]

As shown in Fig. 2, the information processing method according to the
embodiment first acquires the coordinates (step S201). The acquisition unit 101
5 of the information processing apparatus 100 executes an acquisition step of
acquiring the coordinates of the alignment marks of the plurality of sections of
the sample for calibration having regions sectioned by four alignment marks.
[0032]

Next, the coefficient for coordinate transformation is calculated and
10 recorded in association with the section (step S202). The recording unit 102 of
the information processing apparatus 100 executes a recording step of calculating,
for each section, the coefficient for performing coordinate transformation of the
region contained in the section into the coordinate system based on the
coordinates of the alignment marks of the section, and recording the coefficient in
15 association with the section.
[0033]

According to the above configuration, the information processing method is
provided that can manage the position of the specific point with high accuracy.
[0034]

20 (Description of Information Processing Apparatus and Information
Processing Method According to Embodiment 1)

Fig. 5 is a schematic diagram showing the position of a specific point
corresponding to alignment mark coordinates according to Embodiment 1. Fig. 6
is a schematic diagram of the alignment mark coordinates and the specific point
25 before and after calibration according to Embodiment 1, and is a schematic
diagram of global alignment mark coordinates. Fig. 7 is a schematic diagram of
measurement of the alignment mark coordinates after time has passed according
to Embodiment 1. Fig. 8 is a schematic diagram showing an example of
unidirectional measurement and meandering measurement of the alignment mark
30 coordinates according to Embodiment 1. An information processing apparatus
and an information processing method according to Embodiment 1 will be
described with reference to Fig. 5 to Fig. 8.
[0035]

An inspection sample contains a specific point. The specific point may be,

for example, a point that represents the position of a defect detected in the sample, a point that represents the position where a foreign substance attached to the sample is detected, or a point that represents a central position in the sample. Furthermore, a purpose of the specific point is freely selected in accordance with the application of the information processing apparatus, the application of the sample, or the like. The specific point may be read as a specific position. The inspection sample may be different from the sample for calibration. In this case, the sample for calibration is used for information processing on the inspection sample, for inspection calibration, or the like. In the inspection sample, alignment marks need not be provided in a grid in which a plurality of vertical columns and horizontal rows are aligned.

[0036]

As described earlier, accurately acquiring and managing position information about a specific point in the inspection sample, that is, coordinates of the specific point (hereinafter, sometimes referred to as "specific point coordinate values") is desired. Thus, as shown in Fig. 5, it is determined to which section in the sample for calibration, that is, to which region in the inspection sample corresponds to the section, the acquired specific point coordinate values belong, in other words, it is determined which region in the inspection sample corresponding to the region surrounded by four alignment marks in the sample for calibration contains the specific point. This determination may be performed based on a comparison between the acquired specific point coordinate values and the coordinates of the alignment marks of the sample for calibration. In a case where, in the inspection sample, alignment marks are provided in a grid in which a plurality of vertical columns and horizontal rows are aligned in the same way as the sample for calibration, this determination may also be performed based on the coordinate values of the alignment marks in the inspection sample. In this way, it is determined in the determination step which section in the sample for calibration contains the specific point in the inspection sample. The coefficient for performing homography transformation of the specific point coordinate values into calibration reference coordinates (coordinates based on the alignment marks in the section) is obtained and applied to the specific point coordinates for coordinate transformation.

[0037]

In this way, it is possible to acquire, identify, or manage the coordinates of the specific point with high accuracy in a reading step of reading the coefficient associated with the section to which the specific point is determined to belong and a transformation step of transforming the coordinates of the specific point based on the coefficient.

[0038]

The information processing apparatus according to Embodiment 1 includes a determination unit, a reading unit and a transformation unit. The determination unit determines to which section among the plurality of sections in the sample for calibration the specific point in the inspection sample belongs. The reading unit reads the coefficient associated with the section to which the specific point is determined to belong. The transformation unit transforms the coordinates of the specific point based on the coefficient.

[0039]

According to the above configuration, the information processing apparatus and the information processing method is provided that can identify the position of the specific point with high accuracy.

[0040]

As described above, the information processing apparatus according to Embodiment 1 performs coordinate transformation of the coordinates of the specific point based on the coefficient associated with the section in the sample for calibration to which the specific point is determined to belong. The upper diagram of Fig. 6 shows the position of the specific point before the coordinate transformation as a black triangle and the position of the specific point after the coordinate transformation as a white triangle. As shown in Fig. 6, the information processing apparatus according to Embodiment 1 subsequently further transforms the position of the specific point on which coordinate transformation has been performed based on global alignment marks. The global alignment marks are alignment marks provided at the outermost portions of the sample, and represent, for example, the vertices of the four corners. That is, the transformed coordinates obtained in the transformation step are further transformed based on the global alignment marks of the inspection sample. In this way, it is possible to further acquire, identify, or manage the position of the specific point with high accuracy by executing a second transformation step of a second transformation

unit performing further coordinate transformation of the coordinates obtained by transforming the specific point coordinate values using calibration reference coordinates into coordinates based on the global alignment marks.

[0041]

5 As shown in Fig. 7, measurement of the alignment marks is time-dependent. This is due to environmental changes such as temperature, humidity, and pressure in apparatuses. Therefore, in a case where measurement is performed from the top left toward the bottom right cells in Fig. 7, deviation of the measured points increases with proximity to the bottom right. Therefore, the acquisition unit 101
10 preferably acquires the coordinates of the alignment marks of the section by correcting the coordinates using a function based on an elapsed time.

[0042]

 As shown in Fig. 8, in a case where the alignment marks are arranged in a grid, it is preferable to measure adjacent columns of the alignment marks in the
15 same direction. For example, it is assumed that the coordinates of the alignment marks are measured as the coordinates deviate over time in a bottom right direction within a series of measurement times. In this case, the middle column of the cells (second column in the drawing) is measured to lean toward the middle, upon performing the measurement by scanning the columns of the aligned
20 cells in a meandering manner. The first column is scanned in a first direction, the second row is scanned in a second direction opposite to the first direction, and the third row is scanned in the first direction. However, the middle column is measured with even deviation and warping is minimum, by scanning and measuring the adjacent columns in the same direction (that is, scanning the first
25 column, the second column, and the third column all in the first direction). With this, the coordinates of the specific point, after having performed the coordinate transformation based on the coordinates of the alignment marks of the section, become more accurate values, since the alignment mark coordinates of the four points in the section deviate uniformly.

30 [0043]

 The acquisition unit 101 can reduce measurement errors by scanning and measuring the coordinates of the adjacent columns of the alignment marks of the section in the same direction. Note that the acquisition unit 101 may scan and measure the coordinates of a plurality of adjacent columns of a plurality of

alignment marks in the same direction, and at this time, may scan and measure all columns in the same direction.

[0044]

5 Note that the present disclosure is not limited to the embodiments described above and may be changed as appropriate without departing from the gist thereof. For example, the cells are represented by a square, but may take another shape such as a circle or a triangle. The outermost alignment marks are set at four points, but may be more than that.

10 The embodiments can be combined as desirable by one of ordinary skill in the art.

15 From the disclosure thus described, it will be obvious that the embodiments of the disclosure may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the disclosure, and all such modifications as would be obvious to one skilled in the art are intended for inclusion within the scope of the following claims.

WHAT IS CLAIMED IS:

1. An information processing method comprising:
an acquisition step of acquiring coordinates of alignment marks of a
5 plurality of sections of a sample for calibration having regions sectioned by four
alignment marks; and
a recording step of calculating, for each of the plurality of sections, a
coefficient for performing coordinate transformation of a region contained in the
section into a coordinate system based on the coordinates of the alignment marks
10 of the section, and recording the coefficient in association with the section.
2. The information processing method according to claim 1, further
comprising:
a determination step of determining to which section among the plurality of
15 sections in the sample for calibration a specific point in an inspection sample
belongs;
a reading step of reading the coefficient associated with the section to
which the specific point is determined to belong; and
a transformation step of transforming coordinates of the specific point
20 based on the coefficient.
3. The information processing method according to claim 1, wherein in the
acquisition step, coordinates of the alignment marks of the section are further
acquired by correcting the coordinates using a function based on an elapsed time.
25
4. The information processing method according to claim 1, wherein in the
acquisition step, coordinates of adjacent columns of the alignment marks of the
section are further scanned and measured in the same direction.
5. The information processing method according to claim 2, further
30 comprising a second transformation step of transforming the transformed
coordinates obtained in the transformation step, based on global alignment marks
of the inspection sample.

6. The information processing method according to any one of claims 1 to 5, wherein the coordinate transformation is the Helmert transformation, an affine transformation, or a homography transformation.

7. An information processing apparatus comprising:
an acquisition unit configured to acquire coordinates of alignment marks of a plurality of sections of a sample for calibration having regions sectioned by four alignment marks; and

a recording unit configured to calculate, for each of the plurality of sections, a coefficient for performing coordinate transformation of a region contained in the section into a coordinate system based on the coordinates of the alignment marks of the section, and record the coefficient in association with the section.

8. The information processing apparatus according to claim 7, further comprising:

a determination unit configured to determine to which section among the plurality of sections in the sample for calibration a specific point in an inspection sample belongs;

a reading unit configured to read the coefficient associated with the section to which the specific point is determined to belong; and

a transformation unit configured to transform coordinates of the specific point based on the coefficient.

9. The information processing apparatus according to claim 7, wherein in the acquisition unit, coordinates of the alignment marks of the section are further acquired by correcting the coordinates using a function based on an elapsed time.

10. The information processing apparatus according to claim 7, wherein in the acquisition unit, coordinates of adjacent columns of the alignment marks of the section are further scanned and measured in the same direction.

11. The information processing apparatus according to claim 8, further comprising a second transformation unit configured to transform the transformed

coordinates obtained by the transformation unit, based on global alignment marks of the inspection sample.

12. The information processing apparatus according to any one of claims 7
5 to 11, wherein the coordinate transformation is the Helmert transformation, an affine transformation, or a homography transformation.