# EXHIBIT Q

[Bates SAMAMD0038767-796]

[SAMAMD0038767]

Amendment (Request for amendment)
November 12, 1998
To: Chief judge of the Patent Office

1. Opposition No.: Opposition No. Hei 10[1998]-71673
2. Patent No.: Japanese Patent No. 2662377
3. Applicant name: Samsung Electronics Co., Ltd.
   Address of patentee: 416 Umetando, Hachitatsu-ku, Suigen – 1shi, Kinki-do, Korea [transliteration]
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5. Object of Amendment
   Request for Amendment and Amended Specification filed on October 2, 1998

6. Contents of Amendment
   See the Appendix

7. Annexed documents
   (1) Text of "Reasons for amendment" (corrected): original 1 copy and duplicates 2 copies
   (2) Text of Amended Specification (corrected): original 1 copy and duplicates 2 copies

(F7497-P)

[SAMAMD0038768]

Contents of Amendment

(1) Reasons for Amendment in Request for Amendment
"Narrowing of Claims of the patent application" is amended to
"Narrowing of Claims of the patent application and clarification of unclear description".

(2)-①

Claim 1 in the Amended Specification, that is,

"An operating condition setting method characterized by the following facts: it is a method for setting an operating condition in each step of operation of a semiconductor device manufacturing operation performed in lot units,....

Numeric Equation 1

...

Numeric Equation 2

..."

is replaced by the following in order to clarify the unclear description:

"An operating condition setting method characterized by the following facts:

the method is for setting an operating condition in the various steps of operation in a semiconductor device manufacturing operation performed in lot units;

<u>computed value Xtn</u> computed as an average value for the operating condition up to and including the preceding lot is set as the operating condition of the next lot to be loaded in the operation; when the next lot to be loaded is for execution of the nth round of the operation, based on following Numeric Equation 1, accumulative averaging is performed for the optimum value Xti ± ε of each operating condition in execution of (n – 1) rounds of operation up to and including the preceding lot;

in addition, <u>alignment information ExG</u> of the lower layers formed up to and including the preceding step of operation is extracted <u>to correct alignment value Axy of the operation obtained with said computed value Xtn</u>, <u>and the obtained corrected alignment value Axy'</u> is taken into consideration in setting the operating condition; and said corrected alignment value Axy' is computed based on following Numeric Equation 2.

Numeric Equation 1

[SAMAMD0038769]

$$Xtn = \frac{1}{n-1} \sum_{i=1}^{n-1} (Xti \pm \varepsilon)$$

(where, n is a natural number larger than 1

ε is a correction factor obtained by subtracting a target value from the value of the result of execution of the operation

i = 1 to n – 1

Numeric Equation 2

$$Axy' = Axy + (E \times G)$$

(where, Axy is an alignment value set for an operation

E is the error of the former layer with respect to the reference alignment

G is a correlation coefficient indicating the correlation relationship of the offset of the various lower layers, G = 0.00 to 1.00).

(2)-② In the section of Essence of Amendment in the Request for Amendment,

"The description pertaining to Claims 1-6 in the patent application '1A).... 6H)...' is amended to '1A)...3F)...'." is replaced by the following:

"① Amendment item a

The description pertaining to Claims 1-6 in the patent application

'1. An operating condition setting method characterized by the following facts:

A) the method is for setting an operating condition in the various steps of operation in a semiconductor device manufacturing operation performed in lot units;

B) the value computed as an average value for the operating condition up to and including the preceding lot

C) is set as the operating condition of the next lot to be loaded in the operation.

2. D) The operating condition setting method described in Claim 1 characterized by the fact that when the next lot to be loaded is for execution of the nth round of the operation, based on following Numeric Equation 1, accumulative averaging is performed for the optimum value Xti ± ε of each operating condition in execution of

[SAMAMD0038770]

(n – 1) rounds of operation up to and including the preceding lot.

Numeric Equation 1

$$Xtn = \frac{1}{n-1} \sum_{i=1}^{n-1} (Xti \pm \varepsilon)$$

(where, n is a natural number larger than 1

ε is a correction factor obtained by subtracting a target value from the value of the result of execution of the operation

i = 1 to n – 1).

3. E) The operating condition setting method described in Claim 2 characterized by the fact that accumulative averaging is performed only for operations in which the operation execution result value is within the 67.4% of a standard deviation from the target value.

4. F) The operating condition setting method described in any of Claims 1-3 characterized by the fact that the average value of the operating condition is computed using the manufacturing device of the operation.

5. G) The operating condition setting method described in any of Claims 1-4 characterized by the fact that the alignment information of the lower layers formed up to and including the preceding step of operation is extracted and used in determining the corrected alignment value, and the obtained corrected alignment value is also taken into consideration in setting the operating condition.

6. H) The operating condition setting method described in Claim 5 characterized by the fact that said corrected alignment value Axy' is computed based on following Numeric Equation 2.

Numeric Equation 2

$$Axy' = Axy + (E \times G)$$

(where, Axy is an alignment value set for the operation

E is the error of the former layer with respect to the reference alignment

G is a correlation coefficient indicating the correlation relationship of the offset of the various lower layers, G = 0.00 to 1.00)"

should be replaced by the following description:

"1. An operating condition setting method characterized by the following facts:

A) the method is for setting an operating condition in the various steps of operation in

[SAMAMD0038771]

a semiconductor device manufacturing operation performed in lot units;

B) computed value Xtn computed as an average value for the operating condition up to and including the preceding lot

C) is set as the operating condition of the next lot to be loaded in the operation;

D) when the next lot to be loaded is for execution of the nth round of the operation, based on following Numeric Equation 1, accumulative averaging is performed for the optimum value $Xti \pm \varepsilon$ of each operating condition in execution of $(n-1)$ rounds of operation up to and including the preceding lot.

Numeric Equation 1

$$Xtn = \frac{1}{n-1} \sum_{i=1}^{n-1} (Xti \pm \varepsilon)$$

(where, n is a natural number larger than 1

$\varepsilon$ is a correction factor obtained by subtracting a target value from the value of the result of execution of the operation

$i = 1$ to $n - 1$)

G) in addition, alignment information ExG of the lower layers formed up to and including the preceding step of operation is extracted to correct alignment value Axy of the operation obtained with said computed value Xtn, and the obtained corrected alignment value Axy' is taken into consideration in setting the operating condition;

H) and said corrected alignment value Axy' is computed based on following Numeric Equation 2.

Numeric Equation 2

$$Axy' = Axy + (E \times G)$$

(where, Axy is an alignment value set for the operation

E is the error of the former layer with respect to the reference alignment

G is a correlation coefficient indicating the correlation relationship of the offset of the various lower layers, $G = 0.00$ to $1.00$)

[SAMAMD0038772]

2. E) The operating condition setting method described in Claim 1 characterized by the fact that accumulative averaging is performed only for operations in which the operation execution result value is within the 67.4% of a standard deviation from the target value.

3. F) The operating condition setting method described in Claim 1 or 2 characterized by the fact that the average value of the operating condition is computed using the manufacturing device of the operation."

(2)-③ Reasons for the Request for Amendment

The description of "said amendment items... meet the Patent Law, Article 126, Clauses 2-4 cited by the Patent Law, Article 120, Part 4, Clause 3."
is replaced by the following description:

"① Amendment item a

Amendment item a limits the Claims of the patent application to the contents of Claim 6 at the time that the decision to grant a patent was made. It is believed that said Amendment corresponds to narrowing of the Claims defined in the Patent Law, Article 120, Clause 4, Section 2, Proviso No. 1.

Here, amendment item a is for unifying the terminology throughout the entire Specification, and for clarifying the relationship among computed value Xtn in average computing, alignment information ExG, alignment value Axy and corrected alignment value Axy' and the origin of alignment value Axy based on the description of section [0015] of the Specification, and it corresponds to clarification of an unclear description as defined in the Patent Law, Article 120, Section 4, Clause 2, Proviso No. 3.

Consequently, said amendment item a is clearly an amendment within the range of the items described in the Specification initially annexed to the patent application, and the Claims have not been substantially expanded or changed.

The invention specified by the items described in the amended Claims can be granted a patent as an independent part when the patent application is filed. That is, in neither Exhibit No. 1 nor 2 cited in the Notification of Reasons for Revocation, is there a description of the following scheme: the overlay error up to and including the step preceding the current step (that is, the lower layer) is reflected by means of Numeric Equation 2 in the alignment value computed as the optimum value in the current step. Also, said Exhibits show no indication of a creative idea that can easily lead to said scheme.

[SAMAMD0038773]

That is, in Equation P = P' – F(d) in Exhibit No. 1, P' is the condition of the lower layer of the lot. According to this equation, lower layer alignment value P' is corrected with measured value d to obtain alignment value P of the current step. On the other hand, in Numeric Equation 2 of the invention of the present case, Axy is the optimum value computed using Numeric Equation 1. According to this equation, for the lot-averaged computed optimum value Axy obtained using Numeric Equation 1 of the current step, the alignment error of the lot lower layer is also taken into consideration to get Axy'. Consequently, a higher level of correctness is obtained since the error of the lower layer is also absorbed.

As a result, amendment item a meets the requirement defined in the Patent Law, Article 126, Clauses 2-4 as adopted in Patent Law, Article 120, Section 4, Clause 3."

(3)-① Section [0010] in Amended Specification

In order to clarify the unclear description, the following description

"In addition to said setting of the operating condition,... it is possible to set the operating condition even more correctly."

is replaced by the following description:

"in addition to said setting of the operating condition, especially, for the alignment value with respect to the reference layer, the alignment information of the lower layers formed up to and including the preceding lot is extracted, and the alignment value of the operation is corrected by means of said average computing, and the corrected alignment value is also taken into consideration in setting the operating condition, so that the alignment state of each lower layer formed up to and including the preceding step of operation can be reflected in the alignment of the current step of operation, and thus the operating condition can be set even more correctly."

(3)-② Before line 4 counted from the bottom on p. 4 of the Request for Amendment, as amendment item b, the following description is added:

"② Amendment item b

Description of section [0010] in the Specification

'in addition to said setting of the operating condition, especially, for the alignment value with respect to the reference layer, the alignment information of the lower layers formed up to and including the preceding lot is extracted and is used in determining the corrected alignment value of the operation, and the correction value is also taken into consideration in setting the operating condition, so the alignment state of each lower layer formed up to and including the preceding step of operation can be reflected in the alignment of the current step of operation, and thus it is possible to set the operating condition even more correctly.'

[SAMAMD0038774]

is replaced by

'in addition to said setting of the operating condition, especially, for the alignment value with respect to the reference layer, the alignment information of the lower layers formed up to and including the preceding lot is extracted, and the alignment value of the operation is corrected by means of said average computing, and the corrected alignment value is also taken into consideration in setting the operating condition, so the alignment state of each lower layer formed up to and including the preceding step of operation can be reflected in the alignment of the current step of operation, and thus it is possible to set the operating condition even more correctly.' "

(3)-③ After line 18 counted from the bottom on p. 5 of the Request for Amendment, as the reason for the request, the following description is added:

"② Amendment item b

Amendment item b is for unifying the terminology throughout the entire Specification, and for clarifying the relationship among the computed value in average computing, the alignment information, the alignment value and the corrected alignment value and the origin of the alignment value based on the description in section [0015] of the Specification, and it corresponds to clarification of the unclear description as defined in the Patent Law, Article 120, Section 4, Clause 2, Proviso No. 3.

Consequently, said amendment item b is clearly an amendment within the range of the items described in the Specification initially annexed to the patent application, and the Claims have not been substantially expanded or changed.

That is, said amendment item b meets the Patent Law, Article 126, Clauses 2 and 3 cited in the Patent Law, Article 120, Section 4, Clause 3."

(4)-① Section [0015] in the Amended Specification

In order to clarify the unclear description, the following description

"Alignment with the pattern of the lower layer is not necessary as in a lithographic operation... the value of 0.00-1.00 is taken."

is replaced by the following description:

"In an operation of needed alignment with the lower layer pattern, such as in a lithography operation, correct mask alignment is executed with reference to an alignment key formed on the lower layer or the reference layer. This alignment parameter is also

[SAMAMD0038775]

determined using said Numeric Equation 3. However, the state of alignment with respect to the alignment key in the operation up to and including the step of operation preceding the current step of operation influences the alignment in the operation. Consequently, the error in the alignment with respect to the alignment key of the pattern formed in the operation up to and including the preceding step of operation may be reflected in the alignment of the current step of operation. That is, the error of the operation up to and including the preceding step of operation is taken into consideration to correct the alignment relationship parameter of the current step of operation. For this purpose, as shown in following Numeric Equation 4, alignment information obtained by multiplying the error of the former layer (the nearest lower layer formed in the preceding step of operation) with respect to the DAIHON [transliteration] alignment key set on the reference layer by a correlation coefficient (gain) indicating the correlation relationship of the deviation from the reference alignment of each lower layer is taken in consideration for the parameter obtained using Numeric Equation 3.

Numeric Equation 4

$$Axy' = Axy + (E \times G)$$

As can be seen from Numeric Equation 4, corrected alignment value Axy' of the operation is determined by adding the alignment information (ExG) of the lower layer, which is obtained by multiplying alignment error E of the former layer with respect to the reference layer and correlation coefficient G of each lower layer, by alignment value Axy of the parameter ( = Xtn) computed using Numeric Equation 3. This correlation coefficient G is determined to obtain the degree of offset of each lower layer in consideration of error E, and it has a value of 0.00-1.00."

(4)-② Before line 4 counted from the bottom on p. 4 of the Request for Amendment, as amendment item c, the following description is added:

"③ Amendment item c

The following description in section [0015] of the Specification

'In an operation of needed alignment with the lower layer pattern, such as in a lithography operation, correct mask alignment is executed with reference to an alignment key formed on the lower layer or the reference layer. This alignment parameter is also determined using said Numeric Equation 3. However, the state of alignment with respect to the alignment key in the operation up to and including the step of operation preceding the current step of operation influences the alignment in the operation. Consequently, the error in the alignment with respect to the alignment key of the pattern formed in the operation up to and including the preceding step of operation may be reflected in the alignment of the current step of operation. That is, the error of the operation up to and including the preceding step of operation is taken into consideration to correct the alignment relationship parameter of the current step of operation.

[SAMAMD0038776]

For this purpose, as shown in following Numeric Equation 4, the alignment information obtained by multiplying the error of the former layer (the nearest lower layer formed in the preceding step of operation) with respect to the DAIHON alignment key set on the reference layer by the correlation coefficient (gain) indicating the correlation relationship of the deviation from the reference alignment of each lower layer is taken in consideration for the parameter obtained using Numeric Equation 3.

Numeric Equation 4

$$Axy' = Axy + (E \times G)$$

As can be seen from Numeric Equation 4, alignment value Axy' of the operation is determined by adding the alignment information (ExG) of the lower layer, which is obtained by multiplying alignment error E of the former layer with respect to the reference layer and correlation coefficient G of each lower layer, to parameter Axy computed using Numeric Equation 3. This correlation coefficient G is determined to obtain the degree of offset of each lower layer in consideration of error E, and it has a value of 0.00-1.00.'

is replaced by the following description:

'In an operation of needed alignment with the lower layer pattern, such as in a lithography operation, correct mask alignment is executed with reference to an alignment key formed on the lower layer or the reference layer. This alignment parameter is also determined using said Numeric Equation 3. However, the state of alignment with respect to the alignment key in the operation up to and including the step of operation preceding the current step of operation influences the alignment in the operation. Consequently, the error in the alignment with respect to the alignment key of the pattern formed in the operation up to and including the preceding step of operation may be reflected in the alignment of the current step of operation. That is, the error of the operation up to and including the preceding step of operation is taken into consideration to correct the alignment relationship parameter of the current step of operation. For this purpose, as shown in following Numeric Equation 4, the alignment information obtained by multiplying the error of the former layer (the nearest lower layer formed in the preceding step of operation) with respect to the DAIHON alignment key set on the reference layer by the correlation coefficient (gain) indicating the correlation relationship of the deviation from the reference alignment of each lower layer is taken in consideration for the parameter obtained using Numeric Equation 3.

Numeric Equation 4

$$Axy' = Axy + (E \times G)$$

As can be seen from Numeric Equation 4, corrected alignment value Axy' of the operation is determined by adding the alignment information (ExG) of the lower layer, which is obtained by multiplying alignment error E of the former layer with respect to the reference layer and correlation coefficient G of each lower layer, to alignment value Axy of the parameter ( = Xtn) computed using Numeric Equation 3.

[SAMAMD0038777]

This correlation coefficient G is determined to obtain the degree of offset of each lower layer in consideration of error E, and it has a value of 0.00-1.00."

(4)-③ After line 18 on p. 5 of the Request for Amendment, as a reason for the Amendment, the following description is added:

"③ Amendment item c

First, amendment item c is for unifying the terminology. That is, the 'correction value' in the text directly above (Numeric Equation 4) is shown as ExG here. However, in other places, that is, in [0010] and [0021], 'correction value' means Axy'. That is, the terminology is not unified. As a result, the description is unclear. ExG, in the portion below (Numeric Equation 4), is clearly described as alignment information. Consequently, it is unified to 'alignment information'. Also, 'alignment parameter Axy' 1 and 'parameter Axy' are also corrected to 'corrected alignment value Axy' and 'alignment value Axy', respectively, for agreement with the other description portions. These corrections are made to unify the terminology with that described in the initial version of the Specification. Consequently, this corresponds to clarification of unclear description defined in the Patent Law, Article 120, Section 4, Clause 2, Proviso No. 3.

In addition, in order to clarify that Axy in Numeric Equation 4 results from Xtn in Numeric Equation 3, a description of Axy ( = Xtn) is added to the explanatory text. This item can be understood from the explanation of 'computed using Numeric Equation 3' described immediately preceding it, and it clearly corresponds to explanation of unclear description defined in the Patent Law, Article 120, Section 4, Clause 2, Proviso No. 3.

Consequently, amendment item c is an amendment within the range of the items described in the Specification initially annexed to the patent application, and it clearly is not a substantial expansion or change of the Claims of the patent application.

Consequently, amendment item c meets the Patent Law, Article 126, Clauses 2 and 3 cited in the Patent Law, Article 120, Section 4, Clause 3."

[SAMAMD0038778]

{Reasons for Request}

(1) History of establishing registration

Patent application date: May 24, 1995

Decision of granting of patent: April 22, 1997

Registration date: June 13, 1997

Publication date of Gazette with Patent: October 8, 1997 (Japanese Patent No. 2662377)

(2) Reason for Amendment

To narrow the Claims and to clarify the unclear description.

(3) Essence of the Amendment

① Amendment item a

The description pertaining to Claims 1-6 in the patent application

"1. An operating condition setting method characterized by the following facts:

A) the method is for setting an operating condition in the various steps of operation in a semiconductor device manufacturing operation performed in lot units;

B) a value computed as an average value for the operating condition up to and including the preceding lot

C) is set as the operating condition of the next lot to be loaded in the operation.

2. D) The operating condition setting method described in Claim 1 characterized by the fact that when the next lot to be loaded is for execution of the nth round of the operation, based on following Numeric Equation 1, accumulative averaging is performed for the optimum value Xti ± ε of each operating condition in execution of (n – 1) rounds of operation up to and including the preceding lot.

Numeric Equation 1

$$Xtn = \frac{1}{n-1} \sum_{i=1}^{n-1} (Xti \pm \varepsilon)$$

(where, n is a natural number larger than 1

ε is a correction factor obtained by subtracting a target value from the value of the result of execution of the operation

i = 1 to n – 1).

[SAMAMD0038779]

3. E) The operating condition setting method described in Claim 2 characterized by the fact that accumulative averaging is performed only for operations in which the operation execution result value is within the 67.4% of a standard deviation from the target value.

4. F) The operating condition setting method described in any of Claims 1-3 characterized by the fact that the average value of the operating condition is computed using the manufacturing device of the operation.

5. G) The operating condition setting method described in any of Claims 1-4 characterized by the fact that the alignment information of the lower layers formed up to and including the preceding step of operation is extracted and used in determining the corrected alignment value, and the obtained corrected alignment value is also taken into consideration in setting the operating condition.

6. H) The operating condition setting method described in Claim 5 characterized by the fact that said corrected alignment value Axy' is computed based on following Numeric Equation 2.

Numeric Equation 2

$$Axy' = Axy + (E \times G)$$

(where, Axy is an alignment value set for the operation
E is the error of the former layer with respect to the reference alignment
G is a correlation coefficient indicating the correlation relationship of the offset of the various lower layers, G = 0.00 to 1.00)"

should be replaced by the following description:

"1. An operating condition setting method characterized by the following facts:

A) the method is for setting the operating condition in the various steps of operation in a semiconductor device manufacturing operation performed in lot units;

B) <u>computed value Xtn</u> computed as an average value for the operating condition up to and including the preceding lot

C) is set as the operating condition of the next lot to be loaded in the operation;

D) when the next lot to be loaded is for execution of the nth round of the operation, based on following Numeric Equation 1, accumulative averaging is performed for the optimum value Xti ± ε of each operating condition in execution of (n – 1) rounds of operation up to and including the preceding lot.

[SAMAMD0038780]

Numeric Equation 1

$$Xtn = \frac{1}{n-1} \sum_{i=1}^{n-1} (Xti \pm \varepsilon)$$

(where, n is a natural number larger than 1
ε is a correction factor obtained by subtracting a target value from the value of the result of execution of the operation
i = 1 to n – 1)

G) in addition, alignment information ExG of the lower layers formed up to and including the preceding step of operation is extracted to correct alignment value Axy of the operation obtained with said computed value Xtn, and the obtained corrected alignment value Axy' is taken into consideration in setting the operating condition;

H) and said corrected alignment value Axy' is computed based on following Numeric Equation 2.

Numeric Equation 2

$$Axy' = Axy + (E \times G)$$

(where, Axy is an alignment value set for the operation
E is the error of the former layer with respect to the reference alignment
G is a correlation coefficient indicating the correlation relationship of the offset of the various lower layers, G = 0.00 to 1.00)

2. E) The operating condition setting method described in Claim 1 characterized by the fact that accumulative averaging is performed only for operations in which the operation execution result value is within the 67.4% of a standard deviation from the target value.

3. F) The operating condition setting method described in Claim 1 or 2 characterized by the fact that the average value of the operating condition is computed using the manufacturing device of the operation."

② Amendment item b

The following description in section [0010] of the Specification

[SAMAMD0038781]

"in addition to said setting of the operating condition, especially, for the alignment value with respect to the reference layer, the alignment information of the lower layers formed up to and including the preceding lot is extracted and is used in determining the corrected alignment value of the operation, and the correction value is also taken into consideration in setting the operating condition, so the alignment state of each lower layer formed up to and including the preceding step of operation can be reflected in the alignment of the current step of operation, and thus the operating condition can be even more correctly established."

is replaced by

"in addition to said setting of the operating condition, especially, for the alignment value with respect to the reference layer, the alignment information of the lower layer formed up to and including the preceding lot is extracted, and the alignment value of the operation is corrected by means of said average computing, and the corrected alignment value is also taken into consideration in setting the operating condition, so the alignment state of each lower layer formed up to and including the preceding step of operation can be reflected in the alignment of the current step of operation, and thus the operating condition can be even more correctly established."

③ Amendment item c

The following description in section [0015] of the Specification

"In an operation of needed alignment with the lower layer pattern, such as in a lithography operation, correct mask alignment is executed with reference to an alignment key formed on the lower layer or the reference layer. This alignment parameter is also determined using said Numeric Equation 3. However, the state of alignment with respect to the alignment key in the operation up to and including the step of operation preceding the current step of operation influences the alignment in the operation. Consequently, the error in the alignment with respect to the alignment key of the pattern formed in the operation up to and including the preceding step of operation may be reflected in the alignment of the current step of operation. That is, the error of the operation up to and including the preceding step of operation is taken into consideration to correct the alignment relationship parameter of the current step of operation. For this purpose, as shown in Numeric Equation 4 below, the alignment information obtained by multiplying the error of the former layer (the nearest lower layer formed in the preceding step of operation) with respect to the DAIHON alignment key set on the reference layer by the correlation coefficient (gain) indicating the correlation relationship of the deviation from the reference alignment of each lower layer is taken in consideration for the parameter obtained using Numeric Equation 3.

Numeric Equation 4

$$Axy' = Axy + (E \times G)$$

[SAMAMD0038782]

As can be seen from Numeric Equation 4, alignment value Axy' of the operation is determined by adding the alignment information (ExG) of the lower layer, which is obtained by multiplying alignment error E of the former layer with respect to the reference layer and correlation coefficient G of each lower layer, to parameter Axy computed using Numeric Equation 3. This correlation coefficient G is determined to obtain the degree of offset of each lower layer in consideration of error E, and it has a value of 0.00-1.00."

is replaced by the following description:

"In an operation of needed alignment with the lower layer pattern, such as in a lithography operation, correct mask alignment is executed with reference to an alignment key formed on the lower layer or the reference layer. This alignment parameter is also determined using said Numeric Equation 3. However, the state of alignment with respect to the alignment key in the operation up to and including the step of operation preceding the current step of operation influences the alignment in the operation. Consequently, the error in the alignment with respect to the alignment key of the pattern formed in the operation up to and including the preceding step of operation may be reflected in the alignment of the current step of operation. That is, the error of the operation up to and including the preceding step of operation is taken into consideration to correct the alignment relationship parameter of the current step of operation. For this purpose, as shown in Numeric Equation 4 below, the alignment information obtained by multiplying the error of the former layer (the nearest lower layer formed in the preceding step of operation) with respect to the DAIHON alignment key set on the reference layer by the correlation coefficient (gain) indicating the correlation relationship of the deviation from the reference alignment of each lower layer is taken in consideration of the parameter obtained using Numeric Equation 3.

Numeric Equation 4

$$Axy' = Axy + (E \times G)$$

As can be seen from Numeric Equation 4, corrected alignment value Axy' of the operation is determined by adding the alignment information (ExG) of the lower layer, which is obtained by multiplying alignment error E of the former layer with respect to the reference layer and correlation coefficient G of each lower layer, to alignment value Axy of the parameter ( = Xtn) computed using Numeric Equation 3. This correlation coefficient G is determined to obtain the degree of offset of each lower layer in consideration of error E, and it has a value of 0.00-1.00."

(4) Reasons for Request

① Amendment item a

[SAMAMD0038783]

Amendment item a limits the Claims of the patent application to the contents of Claim 6 at the time that the decision to grant the patent was made. It is believed that said Amendment corresponds to narrowing of the Claims as defined in the Patent Law, Article 120, Clause 4, Section 2, Proviso No. 1.

Here, amendment item a is for unifying the terminology throughout the entire Specification, and for clarifying the relationship among computed value Xtn in average computing, alignment information ExG, alignment value Axy and corrected alignment value Axy' and the origin of alignment value Axy based on the description of section [0015] of the Specification, and it corresponds to clarification of unclear description as defined in the Patent Law, Article 120, Section 4, Clause 2, Proviso No. 3.

Consequently, said amendment item a is clearly an amendment within the range of the items described in the Specification initially annexed to the patent application, and the Claims have not been substantially expanded or changed.

The invention specified by the items described in the amended Claims can be granted a patent as an independent part when the patent application is filed. That is, in both Exhibit Nos. 1 and 2 cited in the Notification of Reasons for Revocation, there is no description of the following scheme: the overlay error up to and including the step preceding the current step (that is, the lower layers) is reflected by means of Numeric Equation 2 in the alignment value computed as the optimum value in the current step. Also, said Exhibits show no indication of a creative idea that can easily lead to said scheme.

That is, in Equation P = P' – F(d) in Exhibit No. 1, P' is the condition of the lower layers of the lot. According to this equation, lower layer alignment value P' is corrected with measured value d to obtain alignment value P of the current step. On the other hand, in Numeric Equation 2 of the invention of the present case, Axy is the optimum value computed using Numeric Equation 1. According to this equation, for the lot-averaged computed optimum value Axy using Numeric Equation 1 of the current step, the alignment error of the lot lower layer is also taken into consideration to obtain Axy'. Consequently, a higher level of correctness is obtained since the error of the lower layer is also absorbed.

As a result, amendment item a meets the requirements defined in the Patent Law, Article 126, Clauses 2-4 as adopted in Patent Law, Article 120, Section 4, Clause 3.

② Amendment item b

Amendment item b is for unifying the terminology throughout the entire Specification, and for clarifying the relationship among the computed value in average computing, the alignment information, the alignment value and the corrected alignment value and the origin of the alignment value based on the description of section [0015] of the

[SAMAMD0038784]

Specification, and it corresponds to clarification of unclear description as defined in the Patent Law, Article 120, Section 4, Clause 2, Proviso No. 3.

Consequently, said amendment item b is clearly an amendment within the range of the items described in the Specification initially annexed to the patent application, and the Claims have not been substantially expanded or changed.

That is, said amendment item b satisfies the Patent Law, Article 126, Clauses 2 and 3 cited in the Patent Law, Article 120, Section 4, Clause 3.

③ Amendment item c

First, amendment item c is for unifying the terminology. That is, the "correction value" in the text directly above (Numeric Equation 4) is shown as ExG here. However, in other places, that is, in [0010] and [0021], the "correction value" means Axy'. That is, the terminology is not unified. As a result, the description is unclear. ExG, in the portion below (Numeric Equation 4), is clearly described as alignment information. Consequently, it is unified to "alignment information". Also, "alignment parameter Axy' " and "parameter Axy" also corrected to "corrected alignment value Axy'" and "alignment value Axy", respectively, for agreement with the other description portions. These corrections are made to unify the terminology with that described in the initial version of the Specification. Consequently, this corresponds to clarification of unclear description defined in the Patent Law, Article 120, Section 4, Clause 2, Proviso No. 3.

In addition, in order to clarify that Axy in Numeric Equation 4 results from Xtn in Numeric Equation 3, a description of Axy ( = Xtn) is added in to the explanatory text. This item can be understood from the explanation of "computed using Numeric Equation 3" described immediately preceding it, and it clearly corresponds to explanation of unclear description defined in the Patent Law, Article 120, Section 4, Clause 2, Proviso No. 3.

Consequently, amendment item c is an amendment within the range of the items described in the Specification initially annexed to the patent application, and it clearly is not a substantial expansion or change of the Claims of the patent application.

Consequently, amendment item c meets the Patent Law, Article 126,

[SAMAMD0038785]

Clauses 2 and 3 cited in the Patent Law, Article 120, Section 4, Clause 3.

[SAMAMD0038786]

Document name: Specification
Title of the invention: Operating condition setting method in semiconductor device manufacturing operation

Claims

1. An operating condition setting method characterized by the following facts:

the method is for setting an operating condition in the various steps of operation in a semiconductor device manufacturing operation performed in lot units;

computed value Xtn computed as an average value for the operating condition up to and including the preceding lot is set as the operating condition of the next lot to be loaded in the operation; when the next lot to be loaded is for execution of the nth round of the operation, based on following Numeric Equation 1, accumulative averaging is performed for the optimum value Xti ± ε of each operating condition in execution of (n – 1) rounds of operation up to and including the preceding lot;

in addition, alignment information ExG of the lower layers formed up to and including the preceding step of operation is extracted to correct alignment value Axy of the operation obtained with said computed value Xtn, and the obtained corrected alignment value Axy' is taken into consideration in setting the operating condition; and said corrected alignment value Axy' is computed based on following Numeric Equation 2.

Numeric Equation 1

$$Xtn = \frac{1}{n-1} \sum_{i=1}^{n-1} (Xti \pm \varepsilon)$$

(where, n is a natural number larger than 1
ε is a correction factor obtained by subtracting a target value from the value of the result of execution of the operation
i = 1 to n – 1

Numeric Equation 2

$$Axy' = Axy + (E \times G)$$

(where, Axy is an alignment value set for the operation
E is the error of the former layer with respect to the reference alignment
G is a correlation coefficient indicating the correlation relationship of the offset of the various lower layers, G = 0.00 to 1.00)

[SAMAMD0038787]

2. The operating condition setting method described in Claim 1 characterized by the fact that accumulative averaging is performed only for operations in which the operation execution result value is within the 67.4% of a standard deviation from the target value.

3. The operating condition setting method described in Claim 1 or 2 characterized by the fact that the average value of the operating condition is computed using the manufacturing device of the operation."

Detailed explanation of the invention

[0001]

Industrial application field

The present invention pertains to a manufacturing method for a semiconductor device. More specifically, the present invention pertains to an operating condition setting method that can automatically optimally set an operating condition in a manufacturing operation performed in lot units.

[0002]

Prior art

According to the present semiconductor device manufacturing method, a semiconductor substrate, typically a silicon wafer, is used, and it is subjected to film formation, lithography, etching and other steps of operation performed repeatedly in a continuous operating process, so that semiconductor elements are formed as integrated circuits, with plural semiconductor devices manufactured en bloc on each wafer. When an operation is performed, for example, 25-50 wafers are taken as a lot, and the operation is performed one by one in lot units. In this case, for the steps of operation that are sensitive to changes in an operating condition, such as lithography and etching, before start of operation for the entire lot, a small quantity, e.g., 1-2 wafers, are taken as samples in a sampling operation. Then, based on the results, the operating condition is set for operation for the entire lot. This operating condition setting method is now widely adopted. In the following, an explanation will be given regarding a lithography operation as an example to explain the operating condition setting method by means of said sampling operation.

[0003]

When a lot is to be processed, first, 1-2 sample wafers are selected from the lot, and they are taken as samples for performing the lithography operation, including coating of a photosensitive film, wafer alignment, exposure and development. Then, the results of execution of the sampling operation are measured. That is, the alignment state of the

[SAMAMD0038788]

formed pattern is checked and CD (Critical Dimension) measurement is carried out. From the measurement results, the optimum operating condition is extracted, and the various parameters of the operating condition are reset. Then, using the operating condition reset based on the sampling operation, the lithography operation is performed for the entire lot.

[0004]

Clearly, the operating condition setting method using the sampling operation may also be adopted in various other steps of operation, such as etching and CVD (chemical vapor deposition), etc. For example, in an etching operation, 1-2 pieces of wafers are first taken as samples in performing the sampling operation, in which etching profile measurement, thickness measurement of the residual film, as well as CD measurement, etc. are executed to judge whether the operating condition is appropriate. Based on the results, the various parameters of the operating condition (etching time, etching activation energy value, etc.) are adjusted, followed by execution of the operation for the entire lot.

[0005]

Problems to be solved by the invention

At present, in a semiconductor device manufacturing operation, the aforementioned sampling operation is adopted to set the operating condition. However, this operating condition setting method needs improvement in the following points, and there is a demand for development of new methods.

[0006]

The time of operation needed to perform the sampling operation naturally leads to an increase in the time needed for the overall operation. Consequently, the TAT (Turn Around Time) before completion of a product is increased. Especially, re-processing may be required due to generation of defects in the sampling operation, so a major influence on the TAT results.

[0007]

In fact, for the operator of the equipment of the operation, resetting of the operating condition based on the results of measurement of the sampling operation is a "difficult task". Consequently, due to differences in skill, and other individual factors, errors and mistakes may occur. If the error is significant due to individual differences or if a mistake occurs, mis-setting takes place. In this case, the complete lot in the main operation after the sampling operation may be defective, so that the total lot with a very high cost may have to be discarded. Also, if the defects can be corrected, re-operation is necessary

[SAMAMD0038789]

to rescue the lot. However, in this case, the operation time is greatly increased, and completion is delayed. Also, due to a mistake in communication between successive shifts of workers, the normal operation may be performed while the results of the sampling operation have not been checked. In this case, a succeeding operation may be performed while problems still exist in the reproducibility of the operation. Consequently, said mistake leads to problems in the reliability of finished products. This is undesirable.

[0008]

The objective of the present invention is to solve the aforementioned problems of the prior art by providing an operating condition setting method characterized by the fact that the optimum operating condition can be set without using a sampling operation. That is, by abolishing the sampling operation, it is possible to shorten the TAT and to increase the productivity. Also, because the sampling operation is abolished, man-made errors and mistakes are very unlikely, so that the operation reproducibility, the yield and the manufacturing efficiency can be improved.

[0009]

Means to solve the problems

In order to realize the aforementioned objective, the present invention provides an operating condition setting method characterized by the following facts: the method is for setting an operating condition in the various steps of operation in a semiconductor device manufacturing operation performed in lot units; an average computed value for the operating condition up to and including the preceding lot is set as the operating condition of the next lot to be loaded in the operation. That is, average computing is performed for the operating condition for continuously loaded lots, so errors that occur in executed operations can be smoothed and minimized, and variation in the operation environment, etc. also can be reflected appropriately. Consequently, when the computed value is used, the optimum operating condition can be obtained. In this operating condition setting method, the operating conditions of lots up to and including the preceding lot are accumulated in the manufacturing device of the operation, and the device performs average computing. As a result, man-hours needed to input data computed separately into the manufacturing device can be avoided. Consequently, manual operation can be avoided, and man-made mistakes can be avoided correspondingly. This is preferred.

[0010]

In addition to the aforementioned operating condition setting, especially for the alignment value with respect to a reference layer, the alignment information of the lower layers formed in

[SAMAMD0038790]

the steps of operation up to and including the preceding step of operation is extracted to correct the alignment value of the operation by said average computing, and the corrected alignment value is also taken into consideration in setting the operating condition. As a result, the alignment state of the various lower layers formed in the steps of operation up to and including the preceding step of operation can also be reflected in the alignment of the current step of operation, so the operating condition can be set even more correctly.

[0011]

Application examples

In the following, an explanation will be given regarding an application example of the present invention. In the application example, a lithography operation corresponding to said prior art will be explained.

[0012]

Figure 1 is a flow chart sequentially illustrating the steps of operation of lithography (photolithography) in this application example. After the lot for execution of lithography is loaded, first, as step of operation 101, a photosensitive film coating device is used to coat a photosensitive film on all wafers in the lot. Then, as step of operation 102, each wafer is exposed using a stepper (1:1 projection exposure or close contact/proximity exposure may be adopted). In this case, the operating condition is set according to the operating condition setting method of the present invention and programmed in the stepper. Then, as step of operation 103, the exposed photosensitive film is developed to form a photosensitive film pattern for each wafer. Then, as step of operation 104, whether the photosensitive film pattern has been formed as prescribed is checked. Then, as step of operation 105, based on the result, the operating condition is reset to reflect variation in the operating condition.

[0013]

In the operating condition setting operation, the various parameters of the stepper are adjusted. That is, the parameters to be set are factors that influence alignment and exposure of the wafers, and they include exposure time, focus offset, X-axis/Y-axis shift, X-Y scaling, wafer rotation, and orthogonality. Computing of the optimum values for said parameters is performed as follows.

[0014]

In order to compute the optimum condition for the parameters needed for an exposure

[SAMAMD0038791]

operation, the results of checking the lot detected in step of operation 104 in execution of the operation in the lots up to and including the preceding lot are used. That is, with the results of execution of the operation up to and including the preceding lot, averages are computed for the various parameters used in lots having a resulting value from execution of the operation within a standard deviation of $\pm 1\sigma$ (67.5%) of the target value of the design, and the computed value is set as the operating condition for performing the operation to be executed. It is determined using Numeric Equation 3 below.

Numeric Equation 3

$$Xtn = \frac{1}{n-1}\sum_{i=1}^{n-1}(Xti \pm \varepsilon)$$

......where n is a natural number larger than 1.

In Numeric Equation 3, $\varepsilon$ represents a correction factor obtained by subtracting a target value from the resulting value from execution of the operation. Consequently, ($Xti \pm \varepsilon$) is a corrected value obtained by correcting the error in the operation. When operation is performed according to the corrected value, the corrected value is computed as the optimum value that can be executed free of error. In this application example, the operation parameter Xtn for the nth lot is determined by means of the accumulative average of the correction values (optimum values) $Xti \pm \varepsilon$ ($i = 1$ to $n - 1$) in the ($n - 1$) rounds of normal operation up to and including the preceding lot (operations having result values within the standard deviation).

[0015]

In an operation of needed alignment with the lower layer pattern, such as in a lithography operation, a mask is correctly aligned with reference to an alignment key formed on the lower layer or the reference layer. This alignment parameter is also determined using said Numeric Equation 3. However, the state of alignment with respect to the alignment key in the operation up to and including the step of operation preceding the current step of operation influences the alignment in the operation. Consequently, the error in the alignment with respect to the alignment key of the pattern formed in the operation up to and including the preceding step of operation may be reflected in the alignment of the current step of operation. That is, the error of the operation up to and including the preceding step of operation is taken into consideration to correct the alignment relationship parameter of the current step of operation. For this purpose, as shown in Numeric Equation 4 below, the <u>alignment information</u> obtained by multiplying the error of the former layer (the nearest lower layer formed in the preceding step of operation) with respect to the DAIHON [transliteration] alignment key set on the reference layer by the correlation coefficient (gain) indicating the correlation relationship of the deviation from the reference alignment of each lower layer is taken in consideration for the parameter obtained using Numeric Equation 3.

[SAMAMD0038792]

Numeric Equation 4

$$Axy' = Axy + (E \times G)$$

As can be seen from Numeric Equation 4, corrected alignment value Axy' of the operation is determined by adding the alignment information (ExG) of the lower layer, which is obtained by multiplying alignment error E of the former layer with respect to the reference layer and correlation coefficient G of each lower layer, to alignment value Axy of the parameter (= Xtn) computed using Numeric Equation 3. This correlation coefficient G is determined for taking the degree of offset of each lower layer in consideration for error E, and it has a value of 0.00-1.00.

[0016]

Clearly, said alignment relationship setting is not needed in etching and other operations that do not require alignment precision.

[0017]

The exposure condition and alignment parameter determined with said Numeric Equation 3 and Numeric Equation 4 are input to the stepper for storage, and they are set as the optimum condition of the lithography operation.

[0018]

Figure 2 is a schematic block diagram illustrating the constitution of the stepper used in this example. The stepper comprises host computer (10) that controls the operation of the various parts, exposure part (12) that aligns and exposes the loaded wafers, wafer movement control part (14) that controls movement and positioning of the wafers in the stepper, and driving control part (16) that controls the various operations accompanying exposure in exposure part (12).

[0019]

Said host computer (10) comprises central processing unit (CPU) (18) that controls operation of the various parts, keyboard (19) for inputting control commands and various data to CPU (18), memory (20) for storing the programs for use in CPU (18) and the various data for CPU (18), and monitor (21) that displays the data output from CPU (18).

[0020]

[SAMAMD0038793]

Figure 3 is a control flow chart illustrating the control procedure for the stepper according to the operating condition setting method explained above. This control procedure is stored in memory (20), and, according to this control procedure, CPU (18) controls operation of the various parts. In the following, an explanation will be given regarding lithography operation using the stepper in this example with reference to the control flow chart.

[0021]

When an operation start signal is input to CPU (18) from keyboard (19), first, step 111 is executed to check the input of a corrected alignment value by means of keyboard (19). This correction value is for compensating error according to the alignment state of the lower layers formed up to and including the step of operation preceding the current step of operation, and its value is computed with said Numeric Equation 4. When the correction value is input via keyboard (19), CPU (18) reads the operating condition stored in memory (20), and, by adding the correction value to said operating condition for correction. A new operating condition is set in step 112. Here, if a correction value is not input in step 111, CPU (18) executes step 113 in which input of a signal notifying no need for correction by keyboard (19) is checked. If said signal indicating no need for correction is input, step 114 is performed such that the operating condition stored in memory (20) is read and used as the operating condition of the current operation.

[0022]

Then, CPU (18) executes step 115. In this step of operation, according to the operating condition set in step 112 or step 114, exposure part (12), wafer movement control part (14) and driving control part (16) are controlled, and alignment and exposure are executed sequentially for all wafers in the lot. Once the operating condition is set, the various parts are controlled by CPU (18) just as in the prior art. During execution of step 115, CPU (18) executes step 116 by monitoring the completion of the operation for the object lot. As a result, when completion of the operation for the entire lot is detected, the operation of control of the various parts is finished, and a standby mode is entered or preparation for going to the next lot is implemented.

[0023]

After completion of exposure for the entire lot, development is performed, and whether the photosensitive film pattern has been formed as prescribed is checked. Based on the result of checking, data for setting the operating condition for the next lot are input via keyboard (19),

[SAMAMD0038794]

and are stored in memory (20). The checking result is also reflected in the alignment of the next step of operation.

[0024]

Figure 4 is a control flow chart illustrating the resetting operation (input of correction data) for the operating condition read from memory (20) in step 112 or step 114 shown in Figure 3. That is, it shows the operating condition setting procedure for the next lot after completion of the operation for said one lot.

[0025]

In response to a setting signal for assigning the operating condition setting mode input via keyboard (19), CPU (18) enters the condition setting mode, and step 116 is executed. In this step of operation, various parameters input via keyboard (19) are stored in the corresponding region of memory (20) (that is, the region for storage of the parameters of the operation for the preceding lot). In this case, the input parameters are the corrected values (optimum values) obtained by correcting the various parameters for the preceding lot as aforementioned. The input method may be one in which the measured value data of the results of execution of the operation including the error judged from the result of checking and the correction data for correcting the error are input, respectively, or one in which the corrected value (optimum value) after correction of the error is directly input.

[0026]

Then, CPU (18) executes step 117, in which the operating condition stored and accumulated in memory (10) is read, and the operating condition of the lot to be executed is computed from it. As a result, from the parameters via execution of the operation up to and including the preceding lot, the optimum parameters for use in execution of the next operation are computed based on said Numeric Equation 3. Here, CPU (18) executes step 118, in which the various parameters computed in step 117 are set as the operating condition of the current operation, and the corresponding region of memory (18) [sic; (10)] is overwritten (that is, the region for storage of the operating condition adopted in the operation up to and including the preceding operation). As a result, after completion of the operation for resetting of the operating condition, the standby mode is entered and continues up to and including the next setting.

[0027]

For computing said alignment correction value and corrected value (optimum value) and

[SAMAMD0038795]

for computing the average value, operation is performed using CPU (18) as the same device. As a result, the optimum parameter can be more correctly set, and error in the operation can be further minimized. In the control flow chart shown in Figure 4, the condition setting mode is entered based on key input by means of keyboard (19). However, one may also adopt a scheme in which upon completion of the operation for one lot, flow control is executed automatically and computing and setting of the optimum condition can always be performed for individual lots.

[0028]

According to the operating flow chart shown in Figure 1, steps of operation 102-104 are performed in a single process of operation in wafer units, and, when the error is very large ([the wafers can be] in different lots), the checking result may be instantly reflected in later wafers. In this way, the speed in saving lots can be increased.

[0029]

Effect of the invention

As explained above, according to the present invention, for the equipment operator of an operation, setting of the operating condition is no longer a "difficult task". Instead, the optimum condition can be set by computation based on the operating condition data accumulated until that time. Consequently, by abolishing the sampling operation, the operation times of the various steps of operation can be decreased, and it is possible to shorten TAT and to increase the productivity. Also, because the sampling operation is abolished, man-made errors and mistakes are very unlikely, so the operation reproducibility, the yield and the manufacturing efficiency can be improved. This contributes significantly to reducing cost. In addition, after completion of the operation for each lot, the result can be fed back to the next lot. This may be performed automatically by means of the manufacturing device. Consequently, the chance of mistakes in communication between different shifts of workers when the sampling operation is executed can be avoided, the operation reproducibility is excellent, and improvement in the reliability of finished products is also significantly advanced.

Brief description of the figures

Figure 1 is a flow chart illustrating operation when the present invention is adopted in a lithography operation.

Figure 2

[SAMAMD0038796]

is a schematic block diagram illustrating an example of the constitution of a stepper adopted in a lithography operation.

Figure 3 is a control flow chart illustrating the stepper when the present invention is adopted in a lithography operation.

Figure 4 is a flow chart illustrating the input operation for resetting the operating condition for the stepper when the present invention is adopted in a lithography operation.

Explanation of symbols

10 Host computer
12 Exposure part
14 Wafer movement control part
16 Driving control part
18 Central processing unit (CPU)
20 Memory
21 Monitor (display unit)