



(51) International Patent Classification:

G03F 7/20 (2006.01) G02B 7/02 (2006.01)
G02B 7/00 (2006.01)

(21) International Application Number:

PCT/EP2014/053955

(22) International Filing Date:

28 February 2014 (28.02.2014)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

10 2013 203 338.9 28 February 2013 (28.02.2013) DE
61/770,400 28 February 2013 (28.02.2013) US

(71) Applicant: **CARL ZEISS SMT GMBH** [DE/DE];
Rudolf-Eber-Str. 2, 73447 Oberkochen (DE).

(72) Inventors: **HAUF, Markus**; Hafenberg 4, 89075 Ulm (DE). **ROTHENHÖFER, Gerald**; Lenzhalde 13, 73447 Oberkochen (DE).

(74) Agent: **KARLHUBER, Mathias**; COHAUSZ & FLOR-ACK, Patent- und Rechtsanwälte Partnerschaftsgesellschaft mbB, Bleichstraße 14, 40211 Düsseldorf (DE).

(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))

(54) Title: MODEL-BASED CONTROL OF AN OPTICAL IMAGING DEVICE

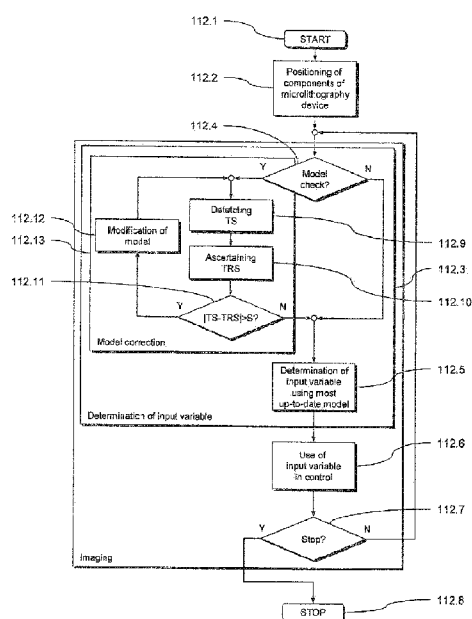


Fig. 2

(57) Abstract: The present invention relates to a method for determining an actual input value of an input variable for a control unit (108) of an imaging device, which is designed in particular for microlithography, said input value being assigned to a first location of the optical imaging device (101), wherein, in a detection step (112.9), at least one actual detection value of a detection variable of at least one detection device (110.6) of the imaging device is detected at a second location, and, in a determination step (112.3), the actual input value of the input variable is determined using the at least one actual detection value and a predefinable first relation (111.3). In a first calculation step (112.10) of the determination step (112.3), an actual computational value of the detection variable at the second location of the detection device (110.6) is ascertained computationally using a second relation (111.4). In a comparison step (112.11) of the determination step (112.3), the actual computational value of the detection variable is then compared with the actual detection value of the detection variable. In a correction step (112.13) of the determination step (112.3), a correction of the first relation (111.3) is then performed as a function of a result of the comparison step (112.11) using a relationship between the first relation (111.3) and the second relation (111.4). Finally, in a second calculation step (112.5) of the determination step (112.3), said second calculation step succeeding the correction step (112.13), the actual input value of the input variable is calculated using the first relation (111.3).

MODEL-BASED CONTROL OF AN OPTICAL IMAGING DEVICE

BACKGROUND OF THE INVENTION

The actual invention relates to a method for determining an actual input value of an input variable for a control unit of an optical imaging device and to a method for driving an active component of the imaging device as a function of the actual input value. The invention can
5 be used in connection with the microlithography used in the production of microelectronic circuits. It furthermore relates to an optical imaging method which can be carried out, inter alia, by means of an optical imaging device according to the invention.

Particularly in the field of microlithography, besides using components embodied with the
10 highest possible precision, it is necessary, inter alia, to keep the position and geometry of the components of the imaging device, that is to say for example the optical elements such as lens elements, mirrors or gratings, as far as possible unchanged during operation, in order to achieve a correspondingly high imaging quality. The high accuracy requirements, which are in the microscopic range of the order of magnitude of a few nanometers or less, are in this
15 case not least a consequence of the constant need to increase the resolution of the optical systems used in the production of microelectronic circuits, in order to advance the miniaturization of the microelectronic circuits to be produced.

In order to achieve an increased resolution, either the wavelength of the light used can be reduced, as is the case for systems which operate in the extreme UV range (EUV) with
20 operating wavelengths in the range of 13 nm, or the numerical aperture of the projection system can be increased. One possibility for appreciably increasing the numerical aperture above the value of one is realized by means of so-called immersion systems, wherein an immersion medium having a refractive index of greater than one is situated between the last optical element of the projection system and the substrate that is intended to be exposed. A
25 further increase in the numerical aperture is possible with optical elements having a particularly high refractive index.

Both with the reduction of the operating wavelength and with the increase in the numerical aperture, there is an increase not just in the requirements made regarding the positioning accuracy and dimensional stability of the optical elements used throughout the course of

operation. There is also an increase, of course, in the requirements with regard to minimizing the imaging errors of the entire optical arrangement.

What is of particular importance in this case, is, of course, the temperature distribution within the components used, in particular within the optical elements, and the possibly resultant
5 deformation of the relevant components, for example of an optical element, and a possible temperature-dictated variation of the refractive index of the relevant optical element.

For an EUV system, it is known from EP 1 477 853 A2 (Sakamoto; the disclosure of which is incorporated herein by reference) to actively counteract the heating of a mirror exclusively usable in such systems, said heating resulting from the incident light, and to actively keep a
10 temperature detected at a specific location in the mirror within specific predefined limits. This is done by means of a temperature adjustment device which is arranged centrally on the rear side of the mirror and which comprises Peltier elements or the like. This solution has the disadvantage firstly that it is not suitable for use with refractive optical elements, such as are used in particular in the case of the immersion systems mentioned, since the central
15 temperature adjustment device would cover the optically used region. Secondly, only the temperature of a single location in the mirror is reliably controlled taking account of the light energy absorbed by the mirror in a more or less stationary state. Further thermal environmental influences, in particular non-stationary and/or locally varying thermal influences, such as can be introduced by an immersion medium and which can cause
20 dynamic or local fluctuations in the temperature distribution in the mirror, are disregarded.

Proceeding from these problems, WO 2007/128835 A1 (Gellrich et al.; the disclosure of which is incorporated by reference herein) proposes, inter alia, using thermal models of the relevant optical elements. In this regard, by way of example, by means of such a thermal model of an optical element, depending on the actual values of a wide variety of influencing
25 variables (such as, for example, the light power actually used, etc.) and/or detection variables (such as, for example, temperatures measured at specific points in the region of the optical element), it is possible to estimate the actual temperature distribution in the optical element. The insights thus gained regarding the temperature distribution in the optical element can then be used as input variables for a control of the imaging device, which drives active
30 components (for example heating elements and/or cooling elements) as a function of said input variables, in order to achieve a desired temperature distribution in the relevant optical element.

What is problematic here is that, firstly, specific influencing variables that influence the temperature distribution, such as, for example, the actual local light power, can be specified only with limited accuracy, while thermal disturbances often cannot be detected at all. This can have the effect that the estimation of the temperature distribution obtained by means of the model and the actual temperature distribution in the optical element deviate from one another to a greater or lesser extent, and possibly even drift further and further apart over time, with the result that it is no longer possible to control the temperature distribution as required.

This circumstance could eventually be counteracted by means of a corresponding refinement of the model, in particular taking into account further influencing variables and/or a larger number of detection points (at which detection variables, such as the temperature, for example, are ascertained). In this case, however, firstly the complexity for creating the thermal model would increase considerably. Furthermore, the calculation effort for ascertaining the input variables of the control and thus the expenditure of time for the driving of the active components would also increase as a result, such that the high dynamic range of the control, especially required in the field of microlithography, may possibly no longer be guaranteed.

BRIEF SUMMARY OF THE INVENTION

Therefore, the present invention is based on the object of providing a method for determining an actual input value of an input variable for a control unit of an optical imaging device, a method for driving an active component of the imaging device, an optical imaging method and an optical imaging device which do not have the abovementioned disadvantages, or have them at least to a lesser extent, and, in particular, in a simple manner enable control of active components of the imaging device to be as precise and dynamic as possible.

The present invention is based on the insight that a precise and dynamic control of an active component of the imaging device using a known first relation between an input variable (assigned to a first location of the imaging device) for the control and predefined reference variables and also using a detected (at a second location of the imaging device) actual value of a detection variable, is made possible if the actually detected value of the detection variable is used firstly to check the actual accuracy of the first relation and, if appropriate, to correct the first relation. Afterward, the input variable for the control can then be determined precisely on the basis of the possibly corrected first relation. In this way, in other words, the

known relation which is used for determining the input variable and which takes account of the dynamic behavior of the system can be matched to the real conditions in the imaging device in order to enable the input variable to be determined as realistically as possible.

According to the invention, the actual accuracy of the first relation can be assessed simply by virtue of the fact that on the basis of a known second relation (which is in a known relationship with the first relation) as a function of the actual value of one or more influencing variables, firstly, an actual computational value of the detection variable at the second location is ascertained computationally (at which second location the actual detection value of the detection variable is detected by means of a corresponding detection device). If a deviation between this computational value (ascertained on the basis of the second relation) and the value of the detection variable actually detected (by means of the detection device) exceeds a predefinable threshold, a corresponding correction of the first relation can then be performed (owing to the known relationship between the first and second relations).

For this correction, it may suffice, in principle, to derive a corresponding correction of the first relation directly from the ascertained deviation on the basis of suitable assessment criteria. By this means a particularly rapid adaptation to the real conditions can be achieved.

Preferably, an iterative procedure is chosen for the correction, wherein, firstly, a corresponding correction of the second relation is derived from the ascertained deviation and/or the temporal course of the ascertained deviation on the basis of suitable assessment criteria. The corrected second relation is then used to calculate anew the computational value of the detection variable at the second location and to compare it with the actually detected value of the detection variable. This iteration is continued until the deviation between the computational value (ascertained on the basis of the respectively corrected second relation) and the actually detected value of the detection variable falls below a predefinable threshold. Afterward, a corresponding correction of the first relation can then be performed owing to the known relationship between the first and second relations.

One or a plurality of assessment criteria can be used for the assessment of the deviation and the resultant correction of the respective relation. In principle, any suitable assessment criteria can be involved in this case. In this regard, temporal assessment criteria can be used, for example, which take into account the temporal development of at least one of the variables which influence the relevant relation. This can involve the detection variable and additionally or alternatively also other influencing variables which influence the relation. It is

likewise possible to take account of the temporal development of the relation itself, as it results, for example, from one or more preceding corrections.

Likewise, additionally or alternatively, spatial assessment criteria can be used for the assessment of the deviation. In this regard, by way of example, it is possible (for a specific
5 point in time) to ascertain the deviations between the computational value and the actually detected value of the detection variable for a plurality of different second locations. On the basis of these deviations, a corresponding correction of the respective relation can then be ascertained and performed.

In this case, moreover, it goes without saying that, if appropriate, it is also possible to perform
10 a dynamic adaptation of the threshold, upon compliance with which the correction process is concluded. For the adaptation of this threshold, too, it is once again possible to use any desired temporal and/or spatial criteria.

The first relation and the second relation can each be, in principle, of any suitable type. In this regard, by way of example, the first relation may reflect the dependence of the input
15 variable on at least the value of the detection variable at the second location (of the detection device). Likewise, additionally or alternatively, by means of the first relation, it is also possible to take into account other influencing variables and/or the temporal course thereof. Also with the second relation arbitrary influencing variables and/or the temporal course thereof can be taken into account.

20 The relationship between the first relation and the second relation can be of any desired type, in principle. In this regard, the first relation can result, for example, at least from parts of the second relation. In variants of the invention that are configured in a particularly simple manner, the first relation and the second relation are in each case part of a mathematical model which was created beforehand for a part of the imaging device, for example a
25 component (such as e.g. an optical element) of the imaging device. Here, the first and second relations correspond to one another in terms of specific constituents (the relationship between the first and second relations resulting therefrom). In this case, it can be provided that, after successful correction of the second relation, only the corresponding constituents of the corrected second relation have to be taken over into the first relation in order to produce
30 the corrected first relation.

This can be realized in a particularly simple manner if the mathematical model is a parameterized model in which the relationship between the first and second relations is

provided by means of at least one model parameter, which, after the second relation has been corrected, then merely has to be taken over into the first relation in order to bring about the correction thereof as well.

In the case of such a parameterized model, the latter can be realized by a set of
5 parameterized differential equations, for example, wherein, for each influencing variable to be taken into account, a transfer function with respect to the input variable to be ascertained can be represented by such a parameterized differential equation.

It should be noted in this context that, if appropriate, it can also be provided that the value of the detection variable that is detected at the second location by means of the detection
10 device does not directly influence the first relation, but rather is used only in connection with the assessment and correction of the second relation, from which the subsequent correction of the first relation then results. Consequently, it may thus be the case that the direct calculation of the input variable that is effected after the correction of the first relation is effected without using the actual value of the detection variable.

15 The invention can be used, in principle, in connection with arbitrary detection variables. In this regard, by way of example, a deformation of a component of the imaging device can be detected by means of a corresponding detection variable which reproduces a change in the spatial relationship between two reference points on the component (as is the case, for example, for the measurement voltage of a strain gauge). It is likewise possible to use a
20 detection variable which is representative of the position and/or orientation of a reference point on the relevant component.

Preferably, the invention is used in connection with detection variables which are representative of a temperature at the second location of the relevant component. A variable which is representative of a temperature at the first location of the relevant component is then
25 preferably likewise used as input variable for the open-loop or closed-loop control in relation to the first location.

In variants of the invention that are configured in a particularly simple manner, the detection variable is a variable which is representative of a temperature at the second location and which is detected by means of a corresponding temperature sensor. The first and second
30 relations are then preferably parts of a parameterized thermal model of a part of the imaging device (for example of an optical element), which reproduces the dependence of the local temperature of the modeled part on one or more influencing variables. The position of the

location for which the local temperature is ascertained (hence, the position of the location under consideration) in this case constitutes a model variable of the model. In the simplest case, the first and second relations then differ merely in the position of the location under consideration (hence, the value of the model variable), while they correspond to each other
5 for the rest (in particular with regard to the values of the model parameters).

The present invention relates to a method for determining an actual input value of an input variable for a control unit of an imaging device, which is designed in particular for microlithography, said input value being assigned to a first location of the optical imaging device. In the method, in a detection step, at least one actual detection value of a detection
10 variable of at least one detection device of the imaging device is detected at a second location, and, in a determination step, the actual input value of the input variable is determined using the at least one actual detection value and a predefinable first relation. In a first calculation step of the determination step, an actual computational value of the detection variable at the second location of the detection device is ascertained computationally using a
15 second relation. In a comparison step of the determination step, the actual computational value of the detection variable is compared with the actual detection value of the detection variable. In a correction step of the determination step, a correction of the first relation is performed as a function of a result of the comparison step using a relationship between the first relation and the second relation. In a second calculation step of the determination step,
20 said second calculation step succeeding the correction step, the actual input value of the input variable is then calculated using the first relation.

The present invention further relates to a method for determining an actual input value of an input variable for a control unit of an optical imaging device, wherein the actual input value is assigned to a first location in the region of a component of the imaging device, which is
25 designed in particular for microlithography. In the method, in a detection step, at least one actual detection value of a detection variable of at least one detection device of the imaging device is detected at a second location in the region of the component, and, in a determination step, the actual input value of the input variable is determined using the at least one actual detection value and a mathematical model of the component. In this case, in a
30 first calculation step of the determination step, an actual computational value of the detection variable at the second location is ascertained computationally using the model. In a comparison step of the determination step, the actual computational value of the detection variable is compared with the actual detection value of the detection variable. In a correction step of the determination step, a correction of the model is performed as a function of a result
35 of the comparison step. Finally, in a second calculation step of the determination step, said

second calculation step succeeding the correction step, the actual input value of the input variable is calculated using the model.

The present invention further relates to a method for controlling at least one active component of an optical imaging device, in particular for microlithography, wherein an actual
5 input value of an input variable for a control unit of the imaging device is determined by a method according to the invention, said input value being assigned to a first component of the imaging device, and the control unit drives at least one active second component of the imaging device as a function of the actual input value, wherein the first calculation step, the comparison step, the correction step and the second calculation step are carried out, in
10 particular, as a function of the occurrence of at least one predefinable temporal or non-temporal event.

The present invention further relates to an optical imaging method, in particular for microlithography, wherein in an optical imaging device, a projection pattern illuminated by means of optical elements of a first group of optical elements is imaged onto a substrate by
15 means of optical elements of a second group of optical elements, wherein a control unit of the imaging device, in particular during the imaging of the projection pattern, drives at least one active second component of the imaging device according to a method according to the invention.

Finally, the present invention further relates to an optical imaging device, in particular for
20 microlithography, comprising a mask device for accommodating a mask comprising a projection pattern, a substrate device for accommodating a substrate, an illumination device having a first group of optical elements for illuminating the projection pattern, a projection device having a second group of optical elements for imaging the projection pattern on the substrate, an active component, and a control unit. The control unit is configured to
25 determine an actual input value of an input variable for the control unit using a method according to the invention, said input value being assigned to a first component of the imaging device. The control unit is, moreover, configured to drive at least one active second component of the imaging device as a function of the actual input value.

Further preferred configurations of the invention become apparent from the dependent claims
30 and the following description of preferred exemplary embodiments, which refers to the accompanying drawings. It is to be noted that any combination of the features disclosed herein, whether recited in the dependent claims or not, is within the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

- Figure 1 is a schematic illustration of a preferred embodiment of the optical imaging device according to the invention with which preferred embodiments of the methods according to the invention can be carried out.
- 5 Figure 2 is a flow chart of a preferred embodiment of an optical imaging method according to the invention which comprises a preferred embodiment of a method according to the invention for controlling an active component of the imaging device from Figure 1 and a preferred embodiment of a method according to the invention for determining an actual input value of an input variable for a control unit of the
- 10 imaging device from Figure 1.
- Figure 3 is a schematic signal flow diagram of a part of the imaging device from Figure 1.

DETAILED DESCRIPTION OF THE INVENTION

A preferred embodiment of the optical imaging device for microlithography according to the invention is described below with reference to Figures 1 to 3.

- 15 Figure 1 shows a highly schematic illustration of a preferred embodiment of the optical imaging device according to the invention in the form of a microlithography device 101. The microlithography device 101 operates with light in the EUV range, i.e. having a wavelength of approximately 5 nm to 20 nm, in the present example approximately 13 nm. It goes without saying, however, that the invention can also be used in connection with any other operating
- 20 wavelengths (in particular below 300 nm, for example 193 nm), such as are typically used in the field of microlithography.

The microlithography device 101 comprises an illumination system 102, a mask device 103, an optical projection system in the form of an objective 104, and a substrate device 105. The illumination system 102 illuminates, by means of a light source (not illustrated) and a first

25 group 102.1 of optical elements (illustrated schematically), a mask 103.1, which is arranged on a mask stage 103.2 of the mask device 103 with a projection light beam (indicated schematically) having the wavelength of 13 nm. A projection pattern is situated on the mask 103.1, which projection pattern is projected with a projection light beam 104.1 (illustrated in a simplified manner), via a second group 106 of optical elements arranged in the objective 104,

onto a substrate in the form of a wafer 105.1 arranged on a wafer stage 105.2 of the substrate device 105.

The objective 104 comprises a second group 106 of optical elements, which is formed by a series of first components in the form of optical elements 106.1 to 106.6. The optical
5 elements 106.1 to 106.6 are held in the housing of the objective 104. Owing to the operating wavelength of 13 nm, the optical elements 106.1 to 106.6 are reflective optical elements, that is to say mirrors or the like.

Not least due to the short operating wavelengths, it is necessary to keep the actual temperature distribution TE within the optical elements 106.1 to 106.6, primarily in the region
10 of the respective optical surface of the optical elements 106.1 to 106.6, during operating (in particular during the imaging of the projection pattern onto the wafer 105.1), within very narrow variation limits around a predefined desired temperature distribution TSE. Otherwise, undesirable deformations of the optical surfaces would result from variations of the temperature distribution and would increase the imaging errors, that is to say would therefore
15 lead to a low imaging quality.

The temperature distribution TE in the respective optical element 106.1 to 106.6 is crucially influenced by the temporal course of the light power of the projection light beam 104.1 and also the position, form and power distribution over the area of incidence of the projection light beam 104.1 on the respective optical surface.

20 In order to comply with the narrow variation limits around a predefined desired temperature distribution TSE, according to the invention an active second component 107.1 to 107.6 is provided for each optical element 106.1 to 106.6, said active second component in each case comprising a temperature adjustment device 107.7. The temperature adjustment device 107.7 of each active second component 107.1 to 107.6 is configured to actively affect the
25 temperature distribution in the assigned optical element 106.1 to 106.6 by actively heating and/or cooling said optical element at at least one location, but typically a plurality of (suitably distributed) locations. The temperature adjustment device 107.7 makes it possible, in particular, to achieve a predefined desired temperature distribution TSE at predefined first locations of the respective optical element 106.1 to 106.6, for example at different points of
30 the optical surface of the respective optical element 106.1 to 106.6, said different points of the optical surface being essential for the imaging quality.

For this purpose, during the imaging of the projection pattern onto the wafer 105.1, the respective active second component 107.1 to 107.6 is driven by a control device 108 using a preferred embodiment of the control method according to the invention. Here, according to a preferred embodiment of the method for determining, according to the invention, such an input variable for different first locations on the respective optical surface of the associated optical element 106.1 to 106.6, a variable is determined as input variable for a control unit 108.1 of the control device 108, which is representative of the actual temperature at this first location of the optical surface, as will be described in greater detail below with reference to Figures 2 and 3.

10 In the present example, a maximum deviation $\Delta TE = 1$ mK from a predefined desired temperature distribution TSE for the optical surfaces of the optical elements 106.1 to 106.6 is complied with owing to the active temperature control by the active second components 107.1 to 107.6 during the operation of the microlithography device 101. By this means, the imaging errors or imaging error variations resulting from a thermally induced deformation can
15 be kept sufficiently small in order to achieve a high imaging quality. It goes without saying, however, that, in other variants of the invention, in particular depending on the thermal deformation behavior of the material used, other, if appropriate higher, maximum deviations are also possible. However, said deviations are preferably at most 10 mK, since particularly high imaging qualities can be achieved therewith.

20 It likewise goes without saying that, in specific variants of the invention, depending on the thermal sensitivity of the individual components, it may also suffice to provide only individual optical elements, if appropriate even only a single one of the optical elements, with such active temperature control. Furthermore, it goes without saying that not just the optical elements of the projection device 104 can be provided with such an active temperature
25 control. Likewise, one or more of the optical elements of the first group 102.1 of optical elements can also be provided with such an active temperature control.

Finally, it goes without saying that such an active temperature control can be provided not only for optical elements but also for other components of the imaging device 101 which can have a negative influence on the imaging quality as a result of thermally induced deformation.

30 It goes without saying in this context that the predefined desired temperature distribution TSE can be chosen arbitrarily. In this regard, it can be chosen such that the optical elements 106.1 to 106.6, even in the case of this desired temperature distribution TSE, have a minimized imaging error at least for one type of imaging error. Likewise, however, it can also

be chosen such that one of the optical elements 106.1 to 106.6, even in the case of this desired temperature distribution TSE, has, at least for one type of imaging error, an imaging error having a magnitude that suffices to reduce or even completely compensate for a corresponding imaging error of the other optical elements 106.1 to 106.6 of the second group
5 106 of optical elements, such that the total imaging error of the objective 104 is minimized at least for one type of imaging error. Such a minimization of the total imaging error is known from EP 0 956 871 A1 (Rupp; the disclosure of which is incorporated herein by reference).

In this context, it furthermore goes without saying that, in other variants of the invention, in addition or as an alternative to the active temperature control, it is also possible to provide
10 other active influencing of one or more first components, in particular one or more optical elements, of the imaging device 101 by means of an assigned active second component. In this regard, one or more of the active second components 107.1 to 107.6 can be designed, for example, to mechanically influence the associated first component, hence, the associated optical element 106.1 to 106.6, for example to influence the position and/or orientation
15 thereof in one or more degrees of freedom (up to and including all six degrees of freedom) and/or to alter its geometry in a targeted manner by means of a local and/or global deformation, in order for example to counteract thermally induced deformations and thus an deterioration of the imaging quality.

Provision can likewise be made for a deterioration of the imaging quality that is caused by a
20 first component, for example the optical element 106.1, to be counteracted by actively influencing one or more of the other first components (which in this case then constitute a third component within the meaning of the present invention), that is to say for example influencing the optical elements 106.2 to 106.6, by an associated active second component 107.2 to 107.6.

25 The basic configuration and sequence of the control of the active second components 107.1 to 107.6 by the control device 108 is described below by way of example on the basis of the active second component 107.6 assigned to the optical element 106.6 (as first component within the meaning of the present invention). However, the same also applies expressly to the other optical elements 106.1 to 106.5 and the active second components 107.1 to 107.5
30 assigned thereto.

The control comprises a thermal control loop 109 comprising a temperature adjustment device 107.7 of the active second components 107.6, a detection device 110.6 and the control device 108. The temperature adjustment device 107.6 comprises a series of

temperature adjustment elements, for example in the form of Peltier elements, which are arranged in a manner distributed over the optical element 106.6 according to the thermal loading impinging on the optical element 106.6 during operation and according to the desired temperature distribution TSE to be achieved.

- 5 The detection device 110.6 comprises a series of temperature sensors arranged in a manner distributed over the optical element 106.6 at second locations of the optical element 106.6. Each temperature sensor detects as detection variable a variable that is representative of the temperature TS at the relevant second location.

10 Here, it is generally not possible to position the temperature sensors directly on the optical surface of the optical element 106.6. Rather, a specific distance typically has to be maintained in order to avoid a disturbance of the optical surface by the temperature sensor. Consequently, the respective first location on the optical surface of the optical element 106.6, which is crucial for the active temperature control, lies at a specific distance from the second location of a temperature sensor of the detection device 110.6.

- 15 On account of this distance between the respective first and second locations, deviations arise in the actual temperature of these two locations, such that the actual measured value TS of the respective temperature sensor at the second location does not directly correspond to the actual real value of the temperature TE at the relevant first location and therefore cannot be used as an input variable for a control module 108.1 of the control device 108, said
20 control module driving the temperature adjustment device 107.7.

In order to take account of this circumstance, a computational estimation TRE of the temperature at the first locations on the optical surface of the optical element 106.6 is performed in the control device 108 by means of a thermal model 111 of the imaging device 101, the respective result of which estimation is then used as a respective input variable for
25 the control module 108.1. The control module 108.1 then drives the temperature adjustment device 107.7 and, if appropriate, further active components which influence the thermal load on the optical element 106.6, such as the illumination device 102, for example, in a corresponding manner in order to keep the deviation ΔTE from the desired temperature distribution TSE within the limits described above.

- 30 Here, the thermal model 111 comprises a thermal model 111.1 of the temperature adjustment device, a thermal model 111.2 of the remaining thermal load acting on the optical element 106.6, a thermal model 111.3 of the optical element and a thermal model 111.4 of the

respective temperature sensor of the detection device 110.6. The respective thermal model 111.1 to 111.4 represents a relationship between one or more model input variable and one or more model output variables, which relationship is known with sufficient accuracy.

In this regard, the thermal model 111.1 of the temperature adjustment device represents the
5 relationship between the actual output variables of the control module 108.1 for the temperature adjustment device 107.7 and the proportion of the actual thermal load distribution on the optical element 106.6 which is caused by the temperature adjustment device 107.7. In this case, it goes without saying that further influencing variables, such as, for example, actual operating parameters of the temperature adjustment device or the like,
10 can be taken into consideration.

Furthermore, the thermal model 111.2 of the remaining thermal load represents the relationship between the actual output variables of the control module 108.1 for the illumination device 102 and the proportion of the actual thermal load distribution on the optical element 106.6 which is caused by the illumination device 102. In this case, too, it goes
15 without saying that further influencing variables, such as, for example, actual operating parameters of the illumination device 102 or the like, can be taken into consideration. Likewise, further heat sources or heat sinks or thermal disturbances eventually leading to a corresponding change in the thermal load distribution on the optical element 106.6 can be taken into consideration by this means.

20 In particular, the temperature distribution of the components and/or (in particular in the case of thermally stabilized components) the average temperature of the components in the surroundings of the optical element 106.6 can be taken into consideration in this case. In particular, the temperature distribution and/or the average temperature of active components, such as, for example, actuators or the like, in the surroundings of the optical element 106.6
25 (in particular the active components which act directly on the optical element 106.6) are of particular interest in this case. Likewise, the thermal crosstalk from and/or to adjacent (eventually actively temperature-adjusted) components, in particular other optical elements, can be taken into account. The same applies to the heat output of adjacent electronic components, in particular of sensor devices, such as temperature sensors or position
30 sensors, for example.

The thermal model 111.3 of the optical element 106.6 represents (as a first relation within the meaning of the present invention) the relationship between the actual thermal load distribution on the optical element 106.6 cumulated from the models 111.1 and 111.2 and the

actual real temperature distribution TE on the optical surface of the optical element 106.6, which results from the impinging cumulated thermal load distribution. In this case, it goes without saying that further influencing variables, such as, for example, actual operating parameters of the optical element 106.6 (itself configured as an active element) or the like,
 5 can be taken into account.

The thermal model 111.4 of the detection device 106.6 represents (as a second relation within the meaning of the present invention) the relationship between the actual thermal load distribution on the optical element 106.6 cumulated from the models 111.1 and 111.2 and the actual real temperature TS at the second location of the respective temperature sensor,
 10 which results from the impinging cumulated thermal load distribution. In this case, it goes without saying that further influencing variables, such as, for example, actual operating parameters of the optical element 106.6 (itself configured as an active element) or the like, can be taken into account.

The two thermal models 111.3 and 111.4 are both based on a thermal mathematical model
 15 which was created beforehand for the entire imaging device 101 or a part of the imaging device 101, for example even only for the optical element 106.6 itself.

In the present case, the thermal models 111.3 and 111.4 are parts of a parameterized model M in the form of a set of k parameterized differential equations, wherein, for each of the k influencing variables IN_k to be taken into account, a transfer function TF_k with respect to the
 20 computational estimation TR of the temperature at predefined points of the optical element 106.6 is represented by such a parameterized differential equation, such that, with the j model parameters p_j and the m model variables v_m , the following applies:

$$M = \sum_k TF_k(IN_k; p_j; v_m). \quad (1)$$

In the present case, therefore, the two thermal models 111.3 and 111.4, on the one hand,
 25 differ in the coordinates of the points for which the computational estimation TR of the temperature is ascertained. In addition, the thermal model 111.4 comprises (ultimately in a position-dependent manner) components which represent or take into account the properties of the detection device 110.6, such as, for example, the arrangement of the detection device 110.6 and/or the temporal response behavior of the detection device 110.6 and/or errors of
 30 the detection device 110.6.

The thermal model 111 can be realized in the control device 108 in any suitable manner. In the present example, it is in the form of corresponding data comprising, in particular, one or more executable programs, stored in one or more storage elements of the control device 108, accessed by one or more processors of the control device 108 in order to perform the
5 functions described.

In order to combat the problem that the computational estimation TRE of the actual temperature distribution on the optical surface of the optical element 106.6 (which is used as an input variable for the control module 108.1 for controlling the temperature adjustment device 107.7), owing to thermal disturbances or drift effects, deviates considerably from the
10 actual real temperature distribution TE on the optical surface of the optical element 106.6, in the present example a correction unit 111.5 is provided, in which the thermal model M is corrected, as described in greater detail below in connection with a preferred exemplary embodiment of the imaging method according to the invention, in particular with reference to Figure 2.

15 As can be seen from Figure 2, the method sequence is firstly started in a step 112.1, while in a subsequent step 112.2 the components of the microlithography device 101 are positioned and oriented, thus resulting in the above-described configuration in which the projection pattern can be imaged on the wafer 105.1 in a subsequent imaging step.

In parallel with the optical imaging of the projection pattern on the wafer 105.1, in a
20 determination step 112.3, using the model M, the value of a variable is ascertained for predefined first locations at the optical surface of the optical element 106.6, which is representative of the actual computational temperature TRE at the optical surface. This value is forwarded in each case as the actual input value of an input variable to the control module 108.1 and used by the latter for driving the temperature adjustment device 107.7 and,
25 eventually, also the illumination device 102.

In a step 112.4, a check is firstly made here to determine whether an event has occurred which necessitates checking the thermal model M. This can be an arbitrary event. In this regard, by way of example, non-temporal events, such as switching on the illumination device 102, starting the imaging process, reaching a predefined number of exposure steps, reaching
30 specific temperatures at specific points of the imaging device 101, etc., can be predefined, upon the occurrence of which the thermal model M is checked. Likewise, of course, arbitrary temporal events, for example the elapsing of a predefined time interval, can initiate the checking of the thermal model M. Furthermore, it goes without saying that continuous

checking of the thermal model M is provided at least in specific operating states of the imaging device 101. Finally, it goes without saying that arbitrary logical combinations of a plurality of such temporal and/or non-temporal events can be predefined.

- 5 If it is established in step 112.4 that no checking of the thermal model M is to be carried out, in a calculation step 112.5, an actual input value of the input variable for the control module 108.1 representative of the actual computational temperature TRE on the optical surface is calculated for the predefined points on the optical surface using the model M currently stored in the control device 108. Herein, the thermal models 111.1, 111.2 and 111.3 are used in the manner described above.
- 10 The value ascertained in this way is respectively forwarded, as the actual input value of an input variable, to the control module 108.1 and used by the latter in a driving step 112.6 for driving the temperature adjustment device 107.7 and, if appropriate, also the illumination device 102.

- 15 In a step 112.7, a check is then made to determine whether the method sequence should be ended. If this is the case, the method sequence ends in a step 112.8. Otherwise, the method jumps back to step 112.4.

- 20 If it is established in step 112.4 that checking of the thermal model M is to be carried out, firstly, in a step 112.9, by means of the temperature sensors of the detection device 110.6, an actual detection value of a detection variable (for example of a measurement voltage) is ascertained at the respective second location of the temperature sensor, said detection variable being representative of the actual temperature TS at said second location.

- 25 Furthermore, in a (first) calculation step 112.10, via the thermal model 111.4 of the respective temperature sensor actually stored in the control device 108 and using the model M, an actual computational value of the temperature TRS for the position of the temperature sensor is calculated. In this case, the thermal models 111.1, 111.2 and 111.4 are used in the manner described above.

It goes without saying that steps 112.9 and 112.10 can, of course, also be carried out in the opposite order or at least section-wise in parallel.

- 30 In a comparison step 112.11, for the respective temperature sensor a check is then made to determine whether the absolute value of the difference between the actually detected

temperature TS and the computational value of the temperature TRS exceeds a predefined threshold value S, i.e. whether the following applies:

$$|TS - TRS| = DT > S. \quad (2)$$

If this is the case for none of the temperature sensors, it is concluded that the actually stored
5 model M corresponds sufficiently well to the real situation as it is detected using the temperature sensors. Consequently, the method jumps to the (second) calculation step 112.5, i.e. the actual input values for the control module 108.1, which are representative of the actual computational temperature TRE on the optical surface, are ascertained using the thermal models 111.1, 111.2 and 111.3 in the manner described above.

10 If the relationship $DT > S$ applies to one of the temperature sensors, it is concluded that the actually stored model M no longer corresponds sufficiently well to the real situation as it is detected using the temperature sensors. Consequently, a model correction is performed in a step 112.12 in order to match the model M to the real situation.

For this model correction, a corresponding correction of the model M is directly derived from
15 the ascertained deviation DT on the basis of suitable assessment criteria, wherein at least one model parameter p_j is correspondingly altered in order to correct the model M.

For the assessment of the deviation DT and the resultant correction of the model parameters p_j , in particular for the decision as to which of the model parameters p_j are altered and the extent to which this takes place, one or more assessment criteria are stored in the correction
20 module 111.5 of the control device 108. Any suitable assessment criteria can be involved here, in principle. In this regard, by way of example, it is possible to use historical or temporal assessment criteria which take into account the temporal development of at least one of the influencing variables which find their entry into the model M.

This can involve, for example, the temporal development of the detection variable detected
25 by means of the detection device 110.6, hence, in the present example, the temperature detected by means of the temperature sensors. Additionally or alternatively, it is also possible to take into account other influencing variables that are taken into account in the model M. Likewise, the temporal development of the model M itself as it arises, for example, from one or more preceding corrections, can influence the assessment and the resultant
30 modification of the model M.

Additionally or alternatively, spatial assessment criteria can also be used for the assessment of the deviation DT. In this regard, by way of example, the deviations DT (existing at a specific point in time) for a plurality of temperature sensors, that is to say therefore the spatial deviation of the modeled temperature distribution from the actual temperature distribution, can suitably influence the assessment and conclusions regarding the required correction of the model M can be drawn on the basis of this spatial distribution of the deviations DT.

This can involve local spatial assessment criteria which, for example, take into account only the relation of the respective deviation DT to the deviations DT of the directly adjacent temperature sensors. Likewise, however, it is also possible, of course, to apply global assessment criteria taking into account the deviations DT for all of the temperature sensors.

Moreover, it goes without saying that, if appropriate, it is also possible to perform a dynamic adaptation of the threshold S, upon compliance with which the correction process is concluded. For the adaptation of this threshold, too, it is once again possible to use any desired temporal and/or spatial criteria. Furthermore, additionally or alternatively, it is possible to provide a spatial distribution for the threshold S, that is to say that different threshold values S can be provided for different temperature sensors.

In principle, in the case of variants with a rapid adaptation, a single correction of the model M or modification of the relevant model parameters p_j may suffice to establish the match between the model M and the real situation. In such a case, after step 112.12, the method would then jump directly to step 112.5, wherein the correspondingly modified model parameters p_j of the model 111.4 are then simply inserted into the model 111.3 in order to determine the input variables (representative of the computational temperature distribution TRE) for the control module 108.1.

Preferably, however, an iterative procedure is chosen for the correction, in which procedure in an iteration step 112.13 after the modification in step 112.12 the method jumps again to step 112.9 and the subsequent step 112.10 is carried out with the last modified model M before the comparison step 112.11 is repeated.

If it emerges in the repeated comparison step 112.11 that the relationship $DT > S$ no longer applies to any of the temperature sensors, it is concluded that the actually stored, modified model M was matched sufficiently well to the real situation such as is detected using the temperature sensors. Consequently, the method jumps to the (second) calculation step 112.5, i.e. the actual input values for the control module 108.1, which are representative of

the actual computational temperature TRE on the optical surface, are calculated in the manner described above using the thermal models 111.1, 111.2 and 111.3.

If, even with the modified model M, the relationship $DT > S$ applies to one of the temperature sensors, it is concluded that even the modified model M does not yet correspond sufficiently
5 well to the real situation such as is detected using the temperature sensors. Consequently, the iteration step 112.13 is repeated starting with step 112.12, in order to perform a further model correction.

This iteration can be repeated until a sufficient approximation of the model M to the real situation is reached. In the comparison step 112.11 it is also possible, however, to check one
10 or more termination criteria, the fulfillment of which then leads to termination of the iteration and continuation of the method with step 112.5. This can be advantageous particularly in the case of momentarily unstable states.

It should be mentioned at this point that the temperature TS detected by means of the temperature sensors of the detection device 110.6, in the present example, need not
15 necessarily directly influence the model M and thus the calculation of the input variables for the control module 108.1. Rather, it may suffice for these temperatures TS to be used, as described, only in connection with the assessment and correction of the model M.

It goes without saying, however, that other variants of the invention can also provide for these temperatures to directly influence the determination of the input variables for the control
20 module. By way of example, a relationship, for example in the form of one or more differential equations, between the temperature TS of the respective temperature sensor and the computational temperature TRE on the optical surface of the optical element can be predefined as a first relation. In this case, the temperature TS of the respective temperature sensor can then be used both for correcting this first relation and directly for ascertaining the
25 input variables for the control module.

It should furthermore be mentioned at this point that the model correction 111.5, if appropriate, can also affect the modeling of the temperature adjustment device 111.1 and/or also the modeling of the rest of the thermal load 111.2, as is illustrated by the dashed lines in Figure 3. This may be the case, in particular, if the model M itself represents a modeling of a
30 majority of the imaging device 101 up to and including the complete modeling of the imaging device 101.

The present invention has been described above on the basis of an example in which an active temperature control is provided for all of the optical elements 106.1 to 106.6 of the second group 106 of optical elements. It should once again be noted at this point, that such an active temperature control, in other variants of the invention, can, of course, be used only
5 for individual optical elements. Likewise, such an active temperature control can additionally or alternatively also be used in connection with one or more of the optical elements of the first group 102.1 of optical elements.

Furthermore, it goes without saying that the active influencing of individual components (or optical elements) can be carried out only as a function of the ascertained temperature
10 distribution of other (for example neighboring) components (or optical elements, respectively). This may be the case, in particular, if a relationship known with sufficient accuracy exists between the ascertained temperature distribution of individual components (or optical elements, respectively) and the temperature distribution of such other components. This may be the case, in particular, if these other components are situated in a thermally
15 correspondingly stable environment.

Furthermore, the present invention has been described above on the basis of an example in which a variable representative of a temperature was used as the detection variable. It should be mentioned again at this point that the invention can, in principle, also be used in connection with any other detection variables. In this regard, by way of example, a
20 deformation of a component of the imaging device can be detected by means of a corresponding detection variable which reproduces a change in the spatial relationship between two reference points on the components (as is the case for example for the measurement voltage of a strain gauge). It is likewise possible to use a detection variable which is representative of the position and/or orientation of a reference point on the relevant
25 component.

The present invention has been described above on the basis of an example in which the groups 102.1 and 106 of optical elements consist exclusively of reflective optical elements. It should be noted at this point, however, that the invention can be applied, of course, in particular for the case of imaging at other operating wavelengths, also to groups of optical
30 elements which comprise refractive, reflective or diffractive optical elements solely or in arbitrary combination.

CLAIMS

1. A method for determining an actual input value of an input variable for a control unit (108) of an imaging device (101), which is designed in particular for microlithography, said input value being assigned to a first location of said optical imaging device (101),
5 wherein,

- in a detection step (112.9), at a second location, at least one actual detection value of a detection variable of at least one detection device (110.6) of the imaging device is detected, and,

- in a determination step (112.3), the actual input value of the input variable is
10 determined using the at least one actual detection value and a predefinable first relation (111.3),

characterized in that,

- in a first calculation step (112.10) of the determination step (112.3), an actual computational value of the detection variable at the second location of the
15 detection device (110.6) is ascertained computationally using a second relation (111.4),

- in a comparison step (112.11) of the determination step (112.3), the actual computational value of the detection variable is compared with the actual detection value of the detection variable,

- in a correction step (112.13) of the determination step (112.3), a correction of the first relation (111.3) is performed as a function of a result of the comparison step (112.11) using a relationship between the first relation (111.3) and the second relation (111.4), and

- in a second calculation step (112.5) of the determination step (112.3), said second
25 calculation step succeeding the correction step (112.13), the actual input value of the input variable is calculated using the first relation (111.3).

2. The method according to claim 1, wherein,

- in the correction step (112.13) in an iteration step, as a function of at least the result of the last preceding comparison step (112.11), a correction of the second
30 relation (111.4) is performed, the first calculation step (112.10) is repeated using

the corrected second relation (111.4), and the comparison step (112.11) is subsequently repeated, and

- the iteration step is repeated as a function of the result of the repeated comparison step (112.11), wherein
- 5 - the iteration step, in particular, is repeated if a predefinable deviation between the actual computational value of the detection variable and the actual detection value of the detection variable is exceeded.

3. The method according to claim 2, wherein

- 10 - the correction of the second relation (111.4) is performed in the iteration step using an optimization algorithm,
- the optimization algorithm, in particular, using at least one optimization criterion from a group of optimization criteria consisting of a historical optimization criterion, a local optimization criterion and a global optimization criterion,
- 15 - the historical optimization criterion, in particular, taking into account a result of at least one previous correction step (112.13) for at least one detection device (110.6) of the detection variable,
- the local optimization criterion, in particular, taking into account at least one result of at least one comparison step (112.11) for at least one further detection device (110.6) of the detection variable located adjacent to the detection device (110.6), and
- 20 - the global optimization criterion, in particular, taking into account a result of a comparison step (112.11) for all detection devices (110.6) of a group of detection devices, wherein the group of detection devices comprises a plurality of detection devices (110.6) of the detection variable which are assigned to a component, in particular to an optical element (106.1 to 106.6), of the optical imaging device.
- 25

4. The method according to any one of claims 1 to 3, wherein

- the first relation (111.3) and/or the second relation (111.4) is a part of a mathematical model (111) of a component (106.1 to 106.6), in particular of an optical element, of the optical imaging device,
- 30 - the mathematical model (111), for different locations of the component (106.1 to 106.6), representing a dependence of the actual computational value of the

detection variable on an actual value of at least one influencing variable forming a model variable.

5. The method according to claim 4, wherein

- 5
- the mathematical model (111) is a parameterized model comprising at least one model parameter and, in particular, at least one parameterized differential equation with the at least one model parameter, wherein,
 - in the correction step (112.13), the at least one model parameter is modified as a function of a result of the comparison step.

6. The method according to claim 5, wherein

- 10
- in the correction step (112.13) in an iteration step, as a function of the result of the last preceding comparison step (112.11), for the correction of the second relation (111.4), the at least one model parameter is modified, the first calculation step (112.10) is repeated using the modified at least one model parameter, and the comparison step (112.11) is subsequently repeated as an actual comparison step,
 - 15 and
 - the iteration step is repeated if the actual comparison step (112.11) establishes that a predefinable deviation between the actual computational value of the detection variable and the actual detection value of the detection variable is exceeded, and
 - 20 - the first relation (111.3) is corrected using the relationship between the first relation (111.3) and the second relation (111.4) if the actual comparison step (112.11) establishes that the predefinable deviation between the actual computational value of the detection variable and the actual detection value of the detection variable is respected.

25 7. The method according to claim 6, wherein

- the first relation (111.3) and the second relation (111.4) respectively comprise the at least one model parameter and, for the correction of the first relation (111.3), the at least one model parameter modified in the last preceding iteration step is used for the first relation (111.3), wherein,
- 30 - in the second calculation step (112.5), the actual input value of the input variable for the first location is calculated using the mathematical model (111).

8. The method according to any one of claims 4 to 7, wherein

- the at least one influencing variable is a variable from a group of influencing variables,
- the group of influencing variables consisting of a variable representative of a light power of an illumination device (102) of the imaging device, a variable representative of a heating power of a heating device (107.7) of the imaging device, a variable representative of a cooling power of a cooling device (107.7) of the imaging device, a variable representative of a temperature distribution in an environment of the component (106.1 to 106.6), and a variable representative of a temperature distribution of an actuator device acting on the component (106.1 to 106.6), a variable representative of an average temperature in an environment of the component (106.1 to 106.6), a variable representative of an average temperature of an actuator device acting on the component (106.1 to 106.6), a variable representative of the thermal crosstalk from and/or to an, in particular temperature-adjusted, adjacent component, in particular an optical element, and a variable representative of a heat power of adjacent electronic components, in particular of sensor devices, in particular temperature sensors or position sensors.

9. The method according to any one of claims 1 to 8, wherein

- the detection variable is a variable representative of a temperature and/or
- the input variable is a variable representative of a temperature.

10. The method according to any one of claims 1 to 9, wherein

- the first relation is a relation between the detection value of the detection variable at the second location and the input variable, and,
- in the second calculation step, the actual input value of the input variable is calculated using the actual detection value and the first relation.

11. The method according to any one of claims 1 to 10, wherein

- the first location is at a distance from the second location, wherein
- the first location, in particular, is unsuitable for an arrangement of the at least one detection device (110.6), and/or

- the first location, in particular, is arranged in the region of an optically effective surface of a component (106.1 to 106.6) of the imaging device.

12. A method for determining an actual input value of an input variable for a control unit (108) of an optical imaging device (101), which is designed in particular for microlithography, the actual input value being assigned to a first location in the region of a component (106.1 to 106.6) of the imaging device, wherein,

- in a detection step (112.9), at least one actual detection value of a detection variable of at least one detection device (110.6) of the imaging device is detected at a second location in the region of the component (106.1 to 106.6), and,

- in a determination step (112.3), the actual input value of the input variable is determined using the at least one actual detection value and a mathematical model (111) of the component (106.1 to 106.6),

characterized in that,

- in a first calculation step (112.10) of the determination step (112.3), an actual computational value of the detection variable at the second location is ascertained computationally using the model (111),

- in a comparison step (112.11) of the determination step (112.3), the actual computational value of the detection variable is compared with the actual detection value of the detection variable,

- in a correction step (112.13) of the determination step (112.3), a correction of the model (111) is performed as a function of a result of the comparison step (112.11), and

- in a second calculation step (112.5) of the determination step (112.3), said second calculation step succeeding the correction step (112.13), the actual input value of the input variable is calculated using the model (111).

13. The method according to claim 12, wherein

- the mathematical model (111), for different locations of the component (106.1 to 106.6), represents a dependence of the actual computational value of the detection variable on an actual value of at least one influencing variable forming a model variable,

- the mathematical model (111), in particular, being a parameterized model comprising at least one model parameter and, in particular, at least one

parameterized differential equation with the at least one model parameter, wherein, in the correction step (112.13), the at least one model parameter is modified as a function of a result of the comparison step.

14. The method according to claim 13, wherein

- 5 - in the correction step (112.13) in an iteration step, as a function of the result of the last preceding comparison step (112.11), for the correction of the model (111), the at least one model parameter is modified, the first calculation step (112.10) is repeated using the modified at least one model parameter, and the comparison step (112.11) is subsequently repeated as an actual comparison step, and
- 10 - the iteration step is repeated, if the actual comparison step (112.11) establishes that a predefinable deviation between the actual computational value of the detection variable and the actual detection value of the detection variable is exceeded, and
- the model (111) with the last modified at least one model parameter is used in the
15 second calculation step (112.5) for calculating the actual input value of the input variable for the first location, if the actual comparison step (112.11) establishes that the predefinable deviation between the actual computational value of the detection variable and the actual detection value of the detection variable is respected.

20 15. The method according any one of claims 12 to 14, wherein

- the at least one influencing variable is a variable from a group of influencing variables, the group of influencing variables consisting of a variable representative of a light power of an illumination device (102) of the imaging device, a variable representative of a heating power of a heating device (107.7) of the imaging
25 device, a variable representative of a cooling power of a cooling device (107.7) of the imaging device, a variable representative of a temperature distribution in an environment of the component (106.1 to 106.6), a variable representative of a temperature distribution of an actuator device acting on the component (106.1 to 106.6), a variable representative of an average temperature in an environment of
30 the component (106.1 to 106.6), a variable representative of an average temperature of an actuator device acting on the component (106.1 to 106.6), a variable representative of the thermal crosstalk from and/or to an, in particular temperature-adjusted, adjacent component, in particular an optical element, and a

variable representative of a heat output of adjacent electronic components, in particular of sensor devices, in particular temperature sensors or position sensors, and/or

- the detection variable is a variable representative of a temperature

5 and/or

- the input variable is a variable representative of a temperature.

16. The method according to any of claims 12 to 15, wherein

- the first location is at a distance from the second location,

10 - the first location, in particular, being unsuitable for an arrangement of the at least one detection device (110.6), and/or

- the first location, in particular, being arranged in the region of an optically effective surface of a component (106.1 to 106.6) of the imaging device.

17. A method for controlling at least one active component of an optical imaging device, in particular for microlithography, wherein

15 - an actual input value of an input variable for a control unit (108.1) of the imaging device is determined using a method according to any one of claims 1 to 16, said input value being assigned to a first component (106.1 to 106.6) of the imaging device, and

20 - the control unit (108.1) drives at least one active second component (107.1 to 107.6, 107.7) of the imaging device as a function of the actual input value,

- the first calculation step (112.10), the comparison step (112.11), the correction step (112.13) and the second calculation step (112.5), in particular, being carried out as a function of the occurrence of at least one predefinable temporal or non-temporal event.

25 18. The method according to claim 17, wherein

- the active second component (107.1 to 107.6, 107.7) is a component from a group of components consisting of a temperature adjustment device (107.7), a positioning device, a deforming device and a detecting device,

30 - the active second component (107.1 to 107.6, 107.7), in particular, being assigned to the first component (106.1 to 106.6), in particular to an optical element, and the

active second component (107.1 to 107.6, 107.7), in particular, being configured to act on the first component (106.1 to 106.6).

19. An optical imaging method, in particular for microlithography, wherein

- in an optical imaging device (101), a projection pattern illuminated by means of optical elements of a first group (102.1) of optical elements is imaged onto a substrate (105.1) by means of optical elements (106.1 to 106.6) of a second group (106) of optical elements,
- a control unit (108.1) of the imaging device, in particular during the imaging of the projection pattern, driving at least one active second component (107.1 to 107.6, 107.7) of the imaging device using a method according to any one of claims 17 and 18.

20. An optical imaging device, in particular for microlithography, comprising

- a mask device (103) for accommodating a mask (103.1) comprising a projection pattern,
- a substrate device (105) for accommodating a substrate (105.1),
- an illumination device (102) having a first group (102.1) of optical elements for illuminating the projection pattern,
- a projection device (104) having a second group (106) of optical elements for imaging the projection pattern on the substrate (105.1),
- an active component (107.1 to 107.6, 107.7), and
- a control unit (108.1), wherein
- the control unit (108.1) is configured to determine an actual input value of an input variable for the control unit (108.1) using a method according to any of claims 1 to 16, said input value being assigned to a first component (106.1 to 106.6) of the imaging device, and
- the control unit (108.1) is configured to drive at least one active second component (107.1 to 107.6, 107.7) of the imaging device as a function of the actual input value.

21. The optical imaging device according to claim 20, wherein

- the active second component (107.1 to 107.6, 107.7) is a component from a group of components consisting of a temperature adjustment device (107.7), a positioning device, a deforming device and a detecting device,
- the active second component (107.1 to 107.6, 107.7), in particular, being assigned to the first component (106.1 to 106.6), in particular to an optical element, and the active component (107.1 to 107.6, 107.7), in particular, being configured to act on the first component (106.1 to 106.6),

and/or

- the active second component (107.1 to 107.6, 107.7), in particular, being assigned to a third component (106.1 to 106.6), in particular to a further optical element, and the active component (107.1 to 107.6, 107.7), in particular, being configured to act on the third component (106.1 to 106.6).

* * * * *

1/3

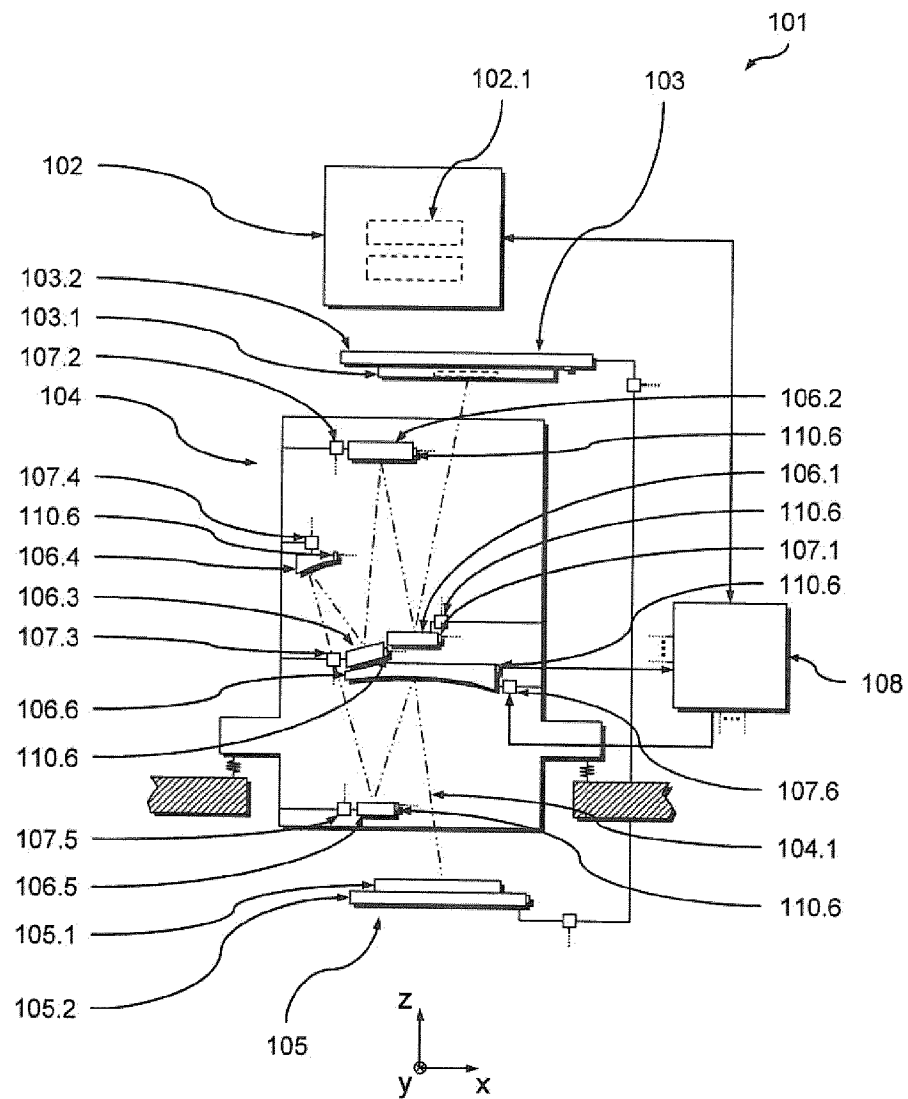


Fig. 1

2/3

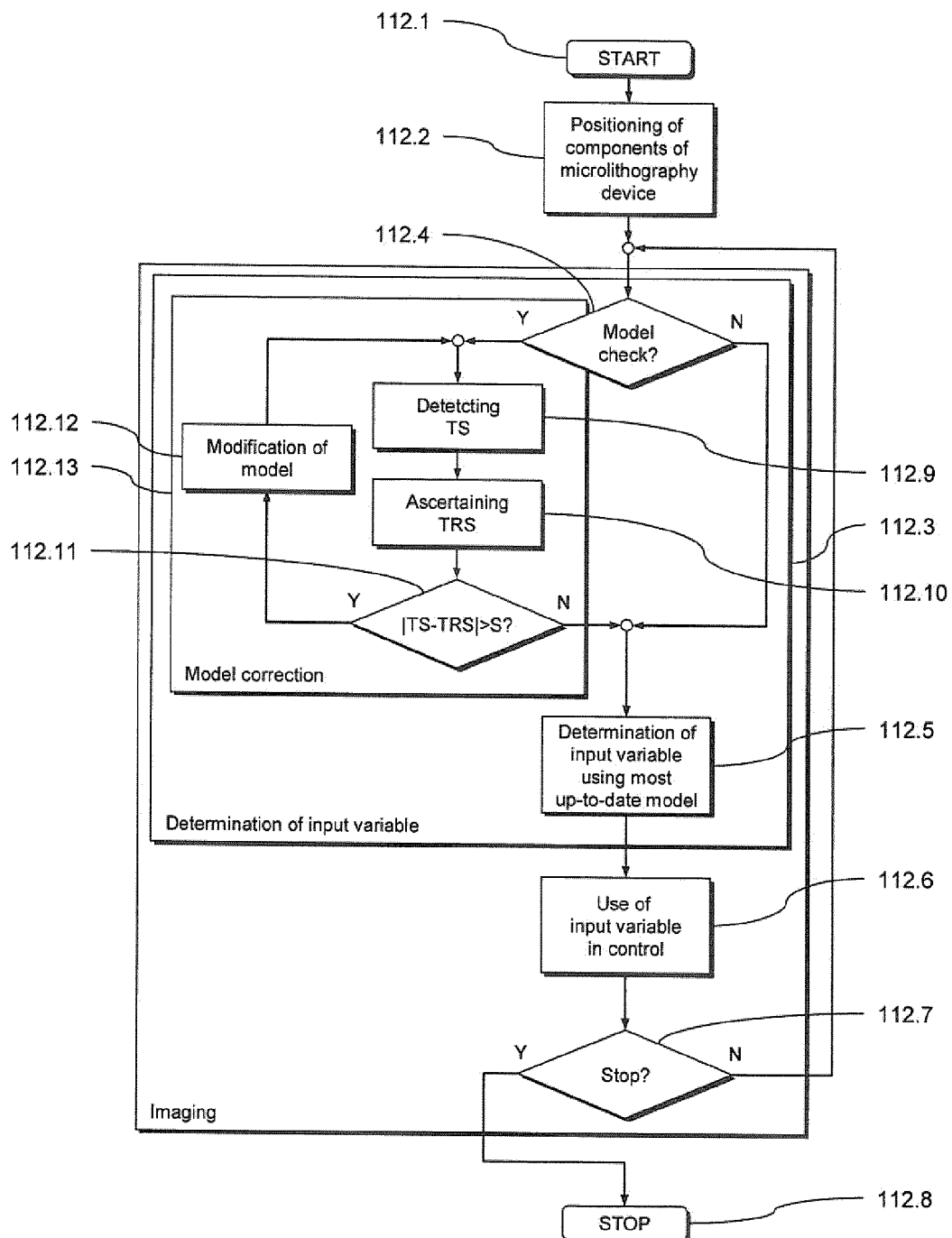


Fig. 2

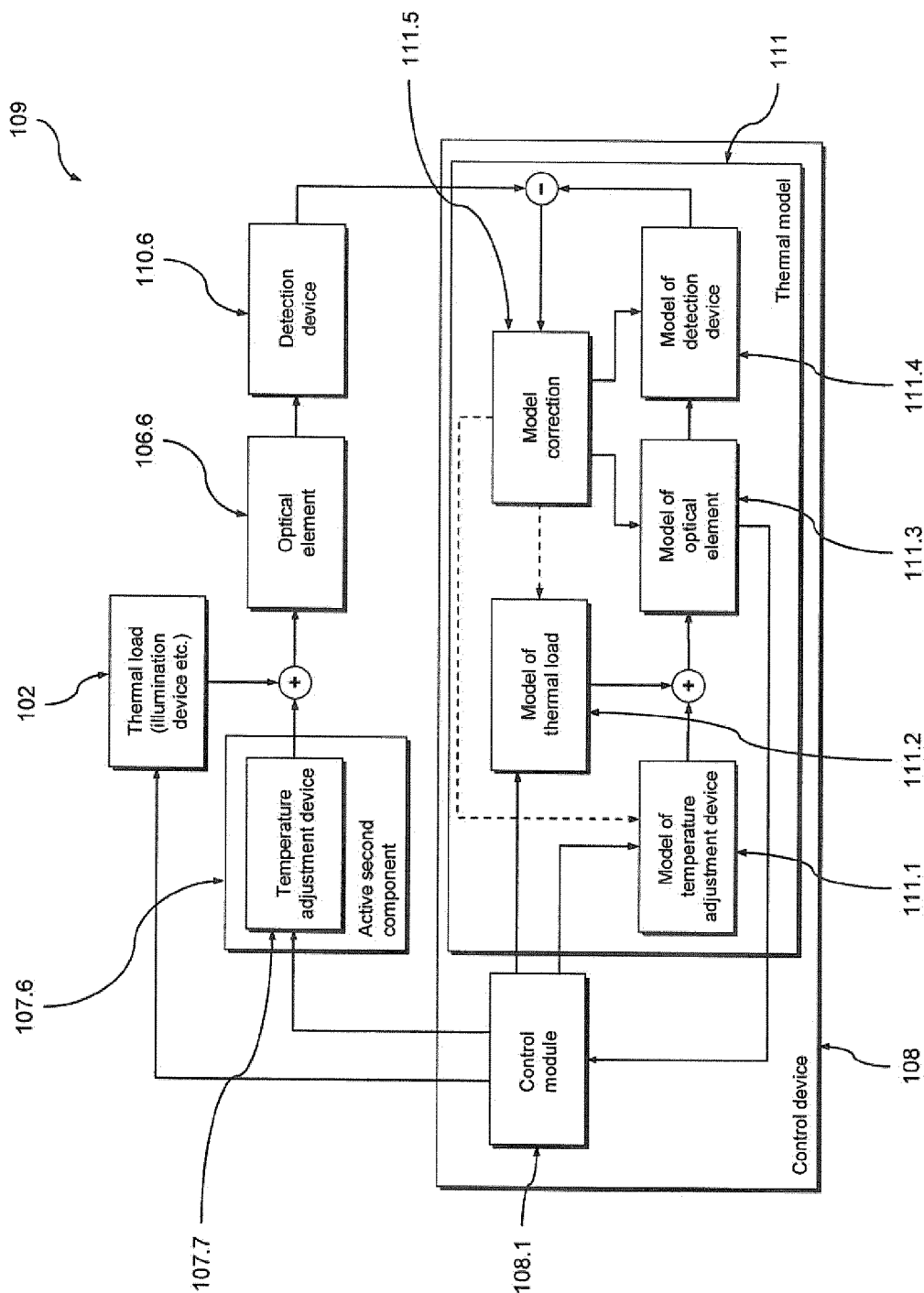


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2014/053955

A. CLASSIFICATION OF SUBJECT MATTER
 INV. G03F7/20 G02B7/00 G02B7/02
 ADD.

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)

G03F H01L G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2009/135385 A1 (GELLRICH BERNHARD [DE] ET AL) 28 May 2009 (2009-05-28) cited in the application paragraphs [0041] - [0045]; figure 2 -----	1-21
A	WO 2009/039883 A1 (ZEISS CARL SMT AG [DE]; KWAN YIM-BUN PATRICK [DE]) 2 April 2009 (2009-04-02) abstract -----	1-21
A	EP 1 513 021 A1 (ASML NETHERLANDS BV [NL]) 9 March 2005 (2005-03-09) paragraphs [0059] - [0061] -----	1-21
A	EP 2 136 250 A1 (ASML NETHERLANDS BV [NL]) 23 December 2009 (2009-12-23) paragraphs [0084] - [0086]; figures 9,10 -----	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

30 April 2014

Date of mailing of the international search report

15/05/2014

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
 NL - 2280 HV Rijswijk
 Tel. (+31-70) 340-2040,
 Fax: (+31-70) 340-3016

Authorized officer

Weckesser, Jens

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2014/053955

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009135385	A1	28-05-2009	CN 101479665 A 08-07-2009
			DE 102006021797 A1 15-11-2007
			EP 2016465 A1 21-01-2009
			JP 2009536452 A 08-10-2009
			JP 2012256921 A 27-12-2012
			KR 20090018939 A 24-02-2009
			TW 200813641 A 16-03-2008
			US 2009135385 A1 28-05-2009
			US 2013114057 A1 09-05-2013
			WO 2007128835 A1 15-11-2007

WO 2009039883	A1	02-04-2009	NONE

EP 1513021	A1	09-03-2005	NONE

EP 2136250	A1	23-12-2009	CN 101609268 A 23-12-2009
			CN 102402132 A 04-04-2012
			EP 2136250 A1 23-12-2009
			JP 4972127 B2 11-07-2012
			JP 5290448 B2 18-09-2013
			JP 2010004039 A 07-01-2010
			JP 2012138630 A 19-07-2012
			KR 20090131669 A 29-12-2009
			SG 158017 A1 29-01-2010
			SG 177192 A1 30-01-2012
			TW 201009506 A 01-03-2010
			US 2009316121 A1 24-12-2009
