

TITLE OF THE INVENTION**EXPOSURE METHOD AND EXPOSURE APPARATUS, AND
DEVICE MANUFACTURING METHOD**

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BACKGROUND OF THE INVENTION**FIELD OF THE INVENTION**

The present invention relates to an exposure method and an exposure apparatus. More particularly, the present invention relates to an exposure method and exposure apparatus used in a lithographic process to manufacture devices such as a semiconductor and a liquid crystal display, and a device manufacturing method using the exposure apparatus.

DESCRIPTION OF THE RELATED ART

15 Conventionally, in the case of manufacturing devices such as semiconductor devices or liquid crystal display devices and the like in a lithographic process, various exposure apparatus have been used. The projection exposure apparatus is commonly used recently. The projection exposure apparatus transfers a pattern formed on a photomask or a reticle (hereinafter to be generally referred to as a "reticle") onto a substrate such as a wafer or a glass plate (hereinafter to be generally referred to as a "wafer" as appropriate) that is coated with a photosensitive agent such as a photoresist.

20 25 As this type of projection exposure apparatus, in recent years, the reduction projection exposure apparatus based on the step-and-repeat method (usually referred to as a stepper) and the projection exposure apparatus which is an improvement

of the stepper based on the step-and-scan method, that is, what is called a scanning stepper, have become widely used. The scanning stepper is capable of performing exposure on a larger field with a smaller optical system, compared with the stepper. Therefore, the projection optical system can be easily built, and an averaging effect is produced due to the relative scanning of the reticle and wafer in respect to the projection optical system, providing advantages such as improvement in distortion or the depth of focus. Thus, it is said that the scanning stepper will become the mainstream in the future.

With the integrated circuits requiring higher integration in recent years, the device rule (practical minimum line width) is also becoming finer, and with the projection exposure apparatus, the demand on improvement in areas such as resolution limit, depth of focus, and line width control accuracy has become an important requirement, along with improvement in throughput.

As a method of improving resolution beyond the resolution limit, the double exposure method is being re-examined, and attempts are being made to use this double exposure method in the KrF excimer laser exposure apparatus or the ArF excimer laser exposure apparatus to perform exposure up to the line and space (L/S) of $0.1\mu\text{m}$. With such double exposure, improvement in two areas, that is, resolution and depth of focus, can be expected.

Multiple exposure, such as the double exposure described above, has been performed mainly for the purpose of improving

the resolution. Therefore, proposals have been made in the past on conditions which contribute to improving the resolution, such as, changing the illumination conditions on the first exposure and the second exposure (for example, refer to Japanese Patent Laid Open No. 04-273245).

However, other conditions, especially the condition that contribute to the improvement in throughput that has nothing to do with improving the resolution, was the same each time exposure was performed. That is, in the process program file which is a type of database to set conditions on exposure, only one type of various control parameters could be set. Therefore, for example, in the case of the scanning stepper, conditions such as the scanning velocity of the respective stages when the reticle and the wafer moves in synchronous, the stepping velocity in between shots, the permissible positional error when settling the set position, or the permissible positional error which is the criteria when judging the synchronous settlement, were the same in the first exposure and the second exposure. In addition, for example, in the case of the stepper, conditions such as the stepping velocity of the wafer stage in between shots, the permissible positional error on settlement of the setting position, were the same in the first exposure and in the second exposure.

Meanwhile, in the case of double exposure, the exposure accuracy required in each exposure was not always the same in the first exposure and the second exposure.

Nevertheless, with the conventional projection exposure apparatus, since exposure was performed under almost the same

conditions as is described above regardless of the exposure accuracy required, even in the case when the throughput should be of more importance than the exposure accuracy, exposure was performed using the same control values as of when resolution was important and high exposure accuracy was required.

As can be seen, until now, when performing double exposure, there was no room for considering improvement in throughput, since too much priority was put on resolution, thus reducing the throughput on double exposure more than necessary.

Similar problems as described above, are occurring also when performing exposure on different layers on the same wafer. That is, usually, on performing exposure on the respective layers, the same control values are used for the scanning velocity, the stepping velocity in between shots, the permissible positional error when settling the set position, or the permissible positional error which is the criteria when judging the synchronous settlement, and the like. In addition, similar problems as above occur for example, when performing exposure based on the stitching method, which is a method to respectively expose a plurality of areas on the same layer where the edges partly overlap one another.

SUMMARY OF THE INVENTION

The present invention has been made in consideration of the circumstances described above, and has as its first object to provide an exposure method and an exposure apparatus that can improve the throughput while maintaining the exposure accuracy at a sufficient level.

And the present invention has as its second object to provide a device manufacturing method that can improve the productivity of highly integrated microdevices.

According to the first aspect of this invention, there
5 is provided an exposure method which performs exposure on a substrate at least twice, the exposure method comprising: performing a first exposure on the substrate with a first control accuracy which corresponds to a first exposure accuracy required; and performing a second exposure on the substrate
10 with a second control accuracy which corresponds to a second exposure accuracy different from the first exposure accuracy required.

According to this method, for example, when exposure is performed that requires high exposure accuracy (one of the
15 first exposure and the second exposure), the control accuracy is to be normal. And when exposure is performed that does not require exposure accuracy so high (the remaining of the first exposure and the second exposure), the control accuracy can be looser than normal. That is, the control accuracy is changed
20 in accordance with the exposure accuracy required for each exposure. Accordingly, when exposure is performed on the same wafer a plurality of times, the throughput can be improved compared with the case when exposure is performed each time with the same control accuracy. In addition, the exposure
25 accuracy can be maintained at a sufficient level.

In this case, the first exposure and the second exposure can be exposure on different layers on the substrate, or the first exposure and the second exposure can be exposure on a

same layer on the substrate.

In the latter case, the first exposure and the second exposure can be a stitching exposure on which patterns are transferred onto adjacent divided areas on the substrate so
5 that the patterns are joined on the substrate, or the first exposure and the second exposure can be a multiple exposure on which patterns are overlaid and transferred onto the same area on the substrate.

With the exposure method of the present invention, the
10 first exposure can be an exposure which is performed on the substrate to set a pattern size, and the second exposure can be an exposure which is performed on the substrate to set a shape of the pattern.

In this description, to "set a pattern size" is a concept
15 including not only setting the pattern line width by resolving a finer line pattern with the accuracy required, but also resolving patterns such as a smaller hole pattern, rectangular pattern with the accuracy required so as to set these pattern size to a desired size.

20 In this case, the second control accuracy can be set looser than the first control accuracy. In such a case, compared with the first control accuracy of the first exposure which sets the pattern size requiring high resolution in general, the second control accuracy of the second exposure which sets
25 the shape of pattern that does not require such high resolution is loosely set. Therefore, in the case of performing exposure on the same wafer likewise with the first exposure and second exposure a plurality of times, the throughput can be improved

when compared with performing each exposure with the same control accuracy. And, the exposure accuracy can also be maintained at a sufficient level.

With the exposure method according to the present invention, in the case the first exposure is an exposure which is performed on the substrate to set a pattern size, and the second exposure is an exposure which is performed on the substrate to set a shape of the pattern, the first exposure and the second exposure can be exposure on different layers on the substrate. Or, the first exposure and the second exposure can be exposure on a same layer on the substrate.

In the latter case, the first exposure and the second exposure can be a stitching exposure on which patterns are transferred onto adjacent divided areas on the substrate so that the patterns are joined on the substrate, or the first exposure and the second exposure can be a multiple exposure on which patterns are overlaid and transferred onto a same area on the substrate.

With the exposure method of the present invention, the control accuracy can include at least one of a movement state of the substrate when position setting a plurality of divided areas on the substrate to predetermined reference positions, a permissible value of positional error on the position setting, a relative alignment precision between the substrate and a mask on which a pattern to be transferred onto the substrate is formed, a movement state when the mask and the substrate is moved in synchronous in a predetermined direction, and a permissible value to determine the settlement when the mask

and the substrate is moved in synchronous.

According to the second aspect of this invention, there is provided an exposure apparatus comprising: an exposure system which irradiates an energy beam onto a mask on which
5 a pattern is formed and transfers the pattern onto a substrate held on a substrate stage; and a control system which totally controls the exposure system and changes a control factor of the exposure system contributing to throughput, in accordance with the exposure accuracy required in each exposure when
10 repetitively performing exposure at least twice on the substrate.

With this apparatus, when exposure is performed at least twice on the same substrate, the control system changes the control factor contributing to throughput (hereinafter referred to as "throughput control factor" as appropriate),
15 in accordance with the exposure accuracy required in each exposure. For example, the throughput control factor is changed so that on exposure when the exposure accuracy required is high the control factor is changed to a state (or a value)
20 in which importance is put on resolution rather than throughput, and on exposure when the exposure accuracy required is moderate, then, on the contrary, the throughput control factor is changed so that priority is put on throughput. Therefore, when exposure is performed at least twice on the same substrate, the throughput
25 can be obviously improved compared with the case when the exposure system is controlled so that each exposure is performed with the same throughput control factor. In addition, in this case, the throughput control factor is changed to a state (or

a value) in which importance is put on throughput only when the exposure accuracy required is moderate, in other words, only when a decrease in exposure accuracy is acceptable to some extent. Thus, the exposure accuracy can be sufficiently
5 maintained.

In this case, the control system can change the control factor of the exposure system contributing to throughput, in accordance with the exposure accuracy required in each layer when performing exposure on different layers on the substrate.
10 Or, the control system can also change the control factor of the exposure system contributing to throughput, in accordance with the exposure accuracy required in each exposure when performing exposure at least twice on the same layer on the substrate.

15 In the latter case, the control system can control the exposure system and perform stitching exposure on which patterns are transferred onto adjacent divided areas on the substrate so that the patterns are joined on the substrate, as exposure performed at least twice on the same layer on the
20 substrate. Or the control system can also control the exposure system and perform multiple exposure on which patterns are overlaid and transferred onto a same area on the substrate, as exposure performed at least twice on the same layer on the substrate.

25 In the latter case, the control system can control the exposure system for the multiple exposure, which includes at least a first exposure to set a pattern size and a second exposure to set a shape of the pattern on the substrate.

In general, in the first exposure to set a pattern size, the exposure accuracy required is high, whereas in the second exposure to set the shape of the pattern, the exposure accuracy required is moderate. Therefore, in this case, the control system changes the throughput control factor so that in the first exposure more importance is put on resolution rather than throughput, and in the second exposure the priority is put on throughput rather than resolution. Furthermore, in the present invention, the order of the first exposure and the second exposure may be reversed. That is, the shape of the pattern may be set in the first exposure, and the pattern size may be set in the second exposure.

With the exposure apparatus in the present invention, the control factor changed by the control system can include at least one of a movement state of the substrate stage when position setting sequentially a plurality of divided areas on the substrate to predetermined reference positions, and a permissible value of positional error on position setting.

"Position setting sequentially a plurality of divided areas on the substrate to predetermined reference positions," in this case, includes both position setting of each shot during stepping operations between shots in the case of the exposure apparatus based on the step-and-repeat method, and position setting of each shot to the starting position for scanning exposure in the case of the exposure apparatus based on the step-and-scan method. And the "movement state of the substrate stage" includes both the velocity and the acceleration of the stage.

If the moving velocity of the substrate stage is accelerated when position setting sequentially a plurality of divided areas on the substrate to predetermined reference positions, that is, if the stepping velocity between shots is accelerated, the time required for exposure of the substrate (exposure time) can be reduced. In the case of increasing the stepping velocity, however, since the substrate stage moves faster within a limited distance (distance in between shots) the absolute value of the acceleration/deceleration velocity becomes larger, thus increasing the vibration on position setting. Naturally, the settling time required for position setting (position setting settlement time) becomes longer. Therefore, it is important to change the movement stage of the substrate stage within an extent so that the throughput is increased as a whole, in consideration of the time reduced by increasing the stepping velocity and the increase in the position setting settlement time.

In addition, if the permissible value of positional error on position setting is larger, then the substrate stage can move into a position setting state in a shorter period of time. Thus, the next operation (such as the exposure operation) can be executed earlier, reducing the total time required for exposure operations, leading to an improvement in throughput.

Also, when the stepping velocity is increased, although the vibration on position setting becomes larger, by increasing the permissible value on position setting in accordance with the increase of stepping velocity, the time required for exposure operations can be reduced without increasing the

position setting settlement time.

With the exposure apparatus in the present invention, in the case the exposure system comprises a projection optical system which projects the energy beam outgoing from the mask
5 onto the substrate, the control factor changed by the control system can include a permissible value of defocus on each exposure.

For example, when the exposure accuracy required is high, the defocus amount allowed on exposure becomes extremely small,
10 and when the exposure accuracy required is moderate, then the defocus amount allowed can be more or less increased, since it hardly has any effect to the exposure. Accordingly, in the case the required exposure accuracy is high, the control system sets a small permissible defocus amount which corresponds to
15 the exposure accuracy level, and in the case the required exposure accuracy is not so high, then sets the permissible defocus amount more or less loose. As a consequence, the pre-focusing to a proximate level becomes shorter in the latter case than in the former, and the time required for exposure
20 can be reduced compared with the case when setting the permissible defocus amount the same in each exposure. And in this case, the exposure accuracy can be maintained at a sufficient level.

With the exposure apparatus in the present invention,
25 in the case the exposure system comprises a pulse laser light source as an energy beam source which emits the energy beam, the control factor changed by the control system can include at least one of an energy intensity and a repetition frequency.

of a pulse light irradiated on the substrate emitted from the pulse laser light source on each exposure.

The "energy intensity", here, includes both the energy amount irradiated on the substrate a unit time per area and the energy amount per pulse. Accordingly, when changing the energy intensity, it includes changing both the illumination on the substrate and the permissible value of the energy intensity dispersion.

If the energy intensity of the energy beam irradiated on the substrate (illumination on the substrate) is stronger, then the time required to expose the substrate can be shortened, therefore, the time required for exposure can be reduced and the throughput can be improved. The energy beam intensity irradiated on the substrate can be increased, by increasing the energy value per pulse from the energy beam source, or by changing the attenuation ratio of the attenuation elements along the optical path between the energy beam source and the substrate. Or it can be increased, for example, by simply changing the illumination conditions from conditions such as ring-shaped illumination or modified illumination to normal illumination. In the case of exposure in which resolution is required, however, it is preferable to perform exposure under the illumination condition such as modified illumination, so that the intensity of the energy beam irradiated on the mask is weaker compared to normal illumination.

In addition, the permissible value of the energy intensity dispersion of the pulse light differs depending on the exposure accuracy required. If the permissible value of

the energy intensity dispersion of the pulse light is large, then the adjustment time can be reduced. Also, if the repetition frequency becomes high, the energy power increases according to the frequency, and re-measurement of the light amount becomes required. However, if the exposure accuracy required is moderate, then the re-measurement can be omitted. Accordingly, the time required for exposure can be reduced, by omitting the re-measurement and the increased energy power due to the increased repetition frequency.

10 With the exposure apparatus in the present invention, the control factor changed by the control system can include a relative alignment precision between the pattern of the mask and the substrate. In such a case, when the exposure accuracy required is high, the control system tightens the relative alignment precision between the mask and the substrate in accordance with the exposure accuracy. And when the exposure accuracy required is not so high, then loosens the relative alignment precision between the mask and the substrate accordingly. Therefore, the total exposure time including the relative alignment of the mask and the substrate can be reduced, compared with the case of setting a tight relative alignment precision between the mask and substrate at all times.

25 The change of the relative alignment precision between the mask and the substrate, here, includes any method if it consequently changes the relative alignment precision between the mask and the substrate, whether the change may be of the mask alignment, or of the substrate alignment.

 In this case, the control factor changed by the control

system can be an alignment mode of at least one of the mask and the substrate. Or, the control factor changed by the control system can be at least one of a number of sample shots and a number of sample marks on alignment of the substrate.

5 Or, the control factor changed by the control system can be a number of sample marks on alignment of the mask.

With the exposure apparatus in the present invention, in the case the exposure system comprises: a mask stage which holds the mask; and a synchronous driving unit which drives

10 the mask stage and the substrate stage in synchronous in a predetermined direction in respect to the energy beam on each exposure, the control factor changed by the control system can include at least one of a movement state of the mask stage and the substrate stage and an intensity of the energy beam

15 corresponding to the movement state irradiated on the substrate, and a permissible value of positional error to determine synchronous settlement of the mask stage and the substrate stage on each exposure.

When the moving velocity (scanning velocity) of the mask

20 stage and substrate stage is increased on exposure, it is obvious that the exposure time (scanning exposure time) is reduced. In this case, however, the intensity (illumination) of the energy beam irradiated on the substrate needs to be stronger according to the increase of scanning velocity, so that the

25 exposure amount on the substrate surface can be maintained at a target value. In such case, the width of the energy beam can be widened in the scanning direction, or the oscillation frequency (repetition frequency) of the energy beam can be

increased. That is, either the intensity of the energy beam, the width, or the oscillation frequency, needs to be changed.

In addition, if the permissible value of positional error to determine synchronous settlement of the mask stage and the substrate stage is increased, the mask stage and the substrate stage moves into a synchronous settlement state at an earlier stage. Therefore, the next exposure operation can be pulled up, which reduces the total exposure time and makes it possible to improve the throughput.

Also, in the case of increasing the scanning velocity, since the movement strokes of the mask stage are usually limited, the acceleration/deceleration before and after scanning becomes larger, thus increasing the synchronous settlement time. In this case, by increasing the permissible value of positional error to determine synchronous settlement according to the increase in scanning velocity, the time required for exposure can be reduced without increasing the synchronous settlement time.

With the exposure apparatus in the present invention, a complicated exposure process program (software) can be made that includes a judgement program to change the control factors on the control systems own judgement. And the program can be incorporated into the control system, according to the exposure accuracy required each time exposure is performed. However, in the case the control system has a process program file to set various parameters to control the exposure system, parameter values for each exposure can be set individually in the process program file. In such a case, the operator

individually sets various parameter values used in each exposure in advance, and the control system controls the exposure system according to the process program file. By doing so, the control factors are changed on each exposure in accordance with the exposure accuracy required. Therefore, there is no need to create any complicated exposure processing files, and only a minor change in the current process program file is required.

Furthermore, in a lithographic process, by using the exposure method in the present invention, exposure is performed with the throughput increased, while maintaining the exposure accuracy at a sufficient level. Accordingly, the throughput of the microdevice and its productivity can be improved, without decreasing the yield of the microdevice on which an extremely fine pattern is formed. Similarly, in a lithographic process, by performing exposure using the exposure apparatus in the present invention, the throughput is increased while maintaining the exposure accuracy at a sufficient level. Therefore, the throughput of the microdevice and its productivity can be improved, without decreasing the yield of the microdevice on which an extremely fine pattern is formed. Accordingly, from another aspect of the present invention, there is provided a device manufacturing method that uses the exposure method or the exposure apparatus of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

Fig. 1 is a schematic view showing the configuration of the exposure apparatus of the embodiment in the present invention;

Fig. 2 is a comparison chart showing the velocity change of the wafer stage during stepping operations in between shots in the case of (a) low-speed stepping, and (b) high-speed stepping;

Fig. 3(A) is a chart corresponding to Fig. 2 (a), showing the positional error against the target value after deceleration has been completed;

Fig. 3(B) is a chart corresponding to Fig. 2 (b), showing the positional error against the target value after deceleration has been completed;

Fig. 4 is a flow chart for explaining an embodiment of a device manufacturing method according to the present invention; and

Fig. 5 is a flow chart showing the processing in step 204 in Fig. 4.

Description of the Preferred Embodiments

An embodiment of the present invention will be described below with reference to Figs. 1 to 3.

Fig. 1 shows the schematic arrangement of an exposure apparatus 100 according to the embodiment. The exposure apparatus 100 is a scanning exposure apparatus based on the step-and-scan method, that is, what is called a scanning stepper.

The exposure apparatus 100 irradiates an energy beam

IL onto the reticle R serving as a mask, on which a pattern is formed. The exposure apparatus 100, is made up of two parts; the exposure system 102 which transfers the pattern of the reticle R onto the wafer W serving as a substrate via the projection optical system PL, and the main controller 20 which serves as a control system and totally controls the exposure system 102.

The exposure system 102 comprises: a pulse laser light source (hereinafter referred to as "light source") 1 such as an ArF excimer laser light source (oscillation wavelength: 193nm), a KrF excimer laser light source (oscillation wavelength: 248nm), or an F2 laser light source (oscillation wavelength: 157nm) serving as an energy beam; an illumination optical system (2, 3, 5 to 8) which structures the illumination system along with the light source 1; a reticle stage RST serving as a mask stage which holds the reticle R illuminated by the energy beam (hereinafter referred to as "exposure light") IL from the illumination system; a projection optical system PL which projects the exposure light IL outgoing from the reticle R; a wafer stage WST serving as a substrate stage which holds the wafer W and moves in an XY two dimensional direction; and a chamber 10 which houses the respective parts structuring the exposure system 102 excluding the light source 1.

The light source 1 is, in actual, arranged in a service room with low degree of cleanliness, separate from the clean room. The respective elements structuring the illumination optical system, and the main body of the exposure apparatus made up of parts such as the reticle stage RST, the projection

optical system PL, and the wafer stage WST, that are housed in the chamber 10, are arranged in the clean room. The light source 1 is connected to the chamber 10 via a light guiding optical system (a light transmission optical system) not shown in Figs. Furthermore, as the light source, an emission line (g line or i line) in the ultraviolet light region emitted from an ultra-high pressure mercury lamp, a metal vapor laser beam, or a harmonic of a YAG laser beam and the like, may be used.

10 The light source 1 has a laser resonator, an energy monitor, an energy controller, a high-voltage power supply, and the like (all of these not shown in Figs). The energy monitor monitors the optical properties of the pulse light from the laser resonator. The energy controller feedback-controls the power supply voltage of the high-voltage power supply so that the output from the energy monitor corresponds to the target value of energy per pulse, which is supplied from the main controller 20. In addition, the energy controller controls the energy supplied to the laser resonator through the high-voltage power supply, thereby also changing the oscillation frequency (repetition frequency). That is, the energy controller sets the oscillation frequency of the light source 1 to a frequency instructed by the main controller 20 in accordance with the control information provided from the main controller 20. The energy controller also feedback-controls the power supply voltage of the high-voltage power supply so that the energy per pulse of the light source 1 becomes the value instructed by the main controller 20 (that

is, the value within the range of the permissible value of the energy intensity dispersion). Such details are disclosed in, for example, Japanese Patent Laid Open No. 08-250402, and the corresponding U.S. Patent No. 5,728,495. The disclosures
5 referred to above, are fully incorporated herein by reference.

In addition, within the light source 1, a shutter is arranged which shields the exposure light IL in accordance with the control information from the main controller 20.

The illumination optical system has an arrangement
10 including: an illumination unifying optical system 2; a relay lens 3; a reticle blind 5; a relay lens 6; a deflection mirror 7; and a condenser lens 8, and the like.

The illumination unifying optical system 2 is, for example, made up of: a beam shaping optical system which is
15 sequentially arranged on the optical path of the exposure light IL; a rough energy adjuster; a fly-eye lens serving as an optical integrator; and an illumination system aperture stop plate, and the like (all of these not shown in Figs). More particularly, the beam shaping optical system shapes the cross-sectional
20 shape of the exposure light IL, which is a pulse beam emitted from the light source 1, so that the exposure light IL can be efficiently incident on the fly-eye lens arranged downstream of the optical path of the exposure light IL. The beam shaping optical system can be configured, for example,
25 of a cylinder lens or beam expander.

In addition, the rough energy adjuster is arranged on the optical path of the exposure light IL, further downstream of the beam shaping optical system. The rough energy adjuster

can, for example, switch the transmittance ($= 1 - \text{attenuation ratio}$) geometrically in multiple steps from 100%. The transmittance of the rough energy adjuster to the exposure light IL is switched by the main controller 20 via the driving
5 unit (not shown in Figs.).

The fly-eye lens is arranged on the optical path of the exposure light IL emitted from the rough energy adjuster, and forms a planar light source consisting of a plurality of point light sources (light source images) on the focal plane of the
10 outgoing surface so that it illuminates the reticle R with a uniform illuminance distribution. That is, a secondary light source is formed. The illumination system aperture stop plate is arranged in the vicinity of the focal plane of the emitting surface of the fly-eye lens. It is made of a disk-shaped member,
15 and on the illumination system aperture stop plate, a plurality of aperture stops are arranged at substantially equal angular intervals. The aperture stops, for example, may have an ordinary circular aperture, or it may have a small circular-shaped aperture for reducing the σ -value, which is
20 a coherence factor. It may also have a ring-shaped aperture for ring-shaped illumination, or a plurality of apertures where the center position of each aperture differ from the optical axis position for modified illumination. In this case, the main controller 20 drives the illumination system aperture
25 stop plate via the driving system (not shown in Figs.) and selectively chooses one of the apertures and arranges it on the optical path of the exposure light IL.

On the optical path of the exposure light IL outgoing

from the illumination system aperture stop plate, a beam splitter having a large transmittance and a small reflectance is arranged. And, further downstream on the optical path, a relay lens system made up of the relay lens 3 and 6 is arranged with the reticle blind 5 arranged in between. The reticle blind 5 is made up of a fixed reticle blind 5A and a movable reticle blind 5B.

The fixed reticle blind 5A is arranged on a surface slightly defocused from the conjugate plane relative to the pattern surface of the reticle R, forming a rectangular opening which sets the illumination area IAR on the reticle R. In addition, in the vicinity of the fixed reticle blind 5A, the movable reticle blind 5B which has an opening variable in position and width in the direction corresponding to the scanning direction is arranged. And at the beginning and the end of the scanning exposure, by further restricting the illumination area IAR through the movable reticle blind 5B, exposure on unnecessary areas can be avoided.

On the optical path of the exposure light IL further downstream of the relay lens 6 structuring the relay optical system, the deflection mirror 7 which deflects the exposure light IL having passed through the relay lens 6 towards the reticle R, is arranged. And further downstream of the deflection mirror 7 on the optical path of the exposure light IL, the condenser lens 8 is arranged.

Furthermore, on the optical path of the light reflected on the beam splitter arranged in the illumination unifying optical system 2, an integrator sensor (not shown in Figs.)

made of a photoelectric conversion element is arranged.

The operations of the illumination optical system having the arrangement described above will be briefly described next. The pulse light emitted from the light source 1, that is, the exposure light IL, is incident on the illumination unifying optical system 2. After the exposure light IL enters the illumination unifying optical system 2, the sectional shape of the exposure light IL is shaped by the beam shaping optical system so that the incident efficiency on the fly-eye lens arranged further downstream is improved. Then, the exposure light IL is incident on the rough energy adjuster. And after the exposure light IL passes through the rough energy adjuster, it enters the fly-eye lens, which creates the secondary light source made up of many point light sources on the outgoing end of the fly-eye lens. The exposure light IL, outgoing from these point light sources, then passes through one of the aperture stops, and proceeds to the rectangular opening of the fixed reticle blind 5A and the movable reticle blind 5B via the relay lens 3. After passing through the fixed reticle blind 5A and the movable reticle blind 5B, it then passes through the relay lens 6, and is bent vertically downward by the deflection mirror 7, to the condenser lens 8, and then reaches the illumination area IRS of the reticle R held on the reticle stage RST, and illuminates the area with uniform distribution.

Meanwhile, the exposure light IL which is reflected on the beam splitter (not shown in Fig.) arranged in the illumination unifying optical system 2, is detected by the integrator sensor, and the photoelectric conversion signal

of the integrator sensor is sent to the main controller 20 via a peak hold circuit and an A/D converter (not shown in Figs.).

Although it is not illustrated in Fig. 1, the respective portions structuring the illumination optical system (2, 3, 5 - 8) are fixed inside a case called an illumination casting. The inside of the illumination casting is sealed from the outside air, and is filled with clean nitrogen gas (N_2) which air (oxygen) concentration does not exceed a few ppb, or an inert gas such as helium gas (He), and the like. This case is supported by a support frame planted on the mainframe (neither of them shown in Figs.).

On the reticle stage RST, the reticle R is fixed, for example, by vacuum chucking. The reticle stage RST, is arranged on a reticle base (not shown in Figs.), and can be finely driven within a plane (XY plane) which is perpendicular to the optical axis IX of the illumination optical system, and scanned within a predetermined range of strokes in the scanning direction (in this case, it is the Y direction being the landscape direction in Fig. 1) by the reticle driving portion 11.

The position (including rotation) of the reticle stage RST within the moving surface is detected at all times at a resolution of around, for example, 0.5 to 1nm, by a reticle laser interferometer 16 via a movable mirror 15 attached on the upper moving surface of the reticle stage RST. The positional information of the reticle stage RST from the reticle laser interferometer 16 is sent to the stage control system 19, and then to the main controller 20. The stage control system

19 drives and controls the reticle stage RST via the reticle driving portion 11 based on the positional information, in accordance with instructions from the main controller 20. Although, it is omitted in the drawings, the reticle base is
5 held by a holding member called Invar, which also holds the projection optical system PL. The Invar is planted on the mainframe (not shown in Figs).

Furthermore, the material used for the reticle R should differ depending on the light source used. That is, in the
10 case of using the ArF excimer laser or the KrF excimer as the light source, materials such as fluorite or synthetic silica glass can be used. However, in the case of using the F₂ laser as the light source, the material used should be of fluoride crystal, such as fluorite.

15 The projection optical system PL is arranged under the reticle stage RST as shown in Fig. 1, and the direction in the optical axis (coincides with the optical axis IX of the illumination optical system) is the Z-axis direction. The projection optical system PL is, for example, a double
20 telecentric reduction system that is made up of a plurality of lens elements arranged along the optical axis direction in predetermined intervals. The projection magnification β of the projection optical system PL is, for example, 1/4 or 1/5. Therefore, when the illumination area IAR of the reticle
25 R is illuminated by the exposure light IL, as is described earlier, the pattern formed on the reticle R is reduced by the projection magnification β , and the reduced image is projected and transferred onto the wafer W coated with resist

(photosensitive agent), on the slit shaped illumination area IA.

The inside of the barrel of the projection optical system PL, is also filled with clean nitrogen gas (N_2) which air (oxygen) concentration does not exceed a few ppb, or an inert gas such as helium gas (He), and the like.

In the case of using the KrF excimer light or the ArF excimer light as the exposure light IL, as the lens elements making up the projection optical system PL, materials such as fluorite or synthetic silica glass can be used. However, in the case of using the F_2 laser as the light source, the material used for the lens of the projection optical system PL should all be made of fluoride crystal, such as fluorite.

The wafer stage WST can be driven freely within the XY two dimensional plane (including the θ_z rotation (rotation around the Z-axis)) via a wafer driving unit 21 which is structured of, for example, a linear motor or a planar motor and the like. A wafer holder 25 is arranged on the wafer stage WST, and the wafer holder 25 holds the wafer W by, for example, vacuum chucking. The wafer holder 25 is, in actual, mounted on the Z leveling table that can be finely driven in the Z direction and the tilt direction in the XY plane (the θ_x direction being the rotational direction around the X-axis and the θ_y direction being the rotational direction around the Y-axis). Accordingly, the position and posture of the wafer W can be controlled in directions of six degrees of freedom, in the X, Y, Z, θ_x , θ_y , and θ_z directions. In addition, although it is omitted in the drawings, a reference mark plate that has

various types of reference marks formed on the plate, is arranged on the Z leveling table (not shown in Figs.). The surface of the reference mark plate, is almost the same level as of the surface of the wafer W.

5 In addition, the position of the wafer stage WST within the XY plane is detected at all times at a resolution of around, for example, 0.5 to 1nm, by a wafer laser interferometer 31 via a movable mirror 27. The positional information (or the velocity information) of the wafer stage WST is sent to the
10 stage control system 19, and then to the main controller 20. The stage control system 19 drives and controls the wafer stage WST via the wafer driving portion 21 based on the positional information (or the velocity information), in accordance with instructions from the main controller 20.

15 On the side surface of the barrel of the projection optical system PL, an alignment optical system ALG serving as a mark detection system based on the off-axis method is arranged. As the alignment optical system ALG, an alignment sensor which
20 measures the position of the mark by illuminating the mark with a broadbanded light such as a halogen lamp and image processing the mark image, that is, FIA (field Image Alignment) system, is used. The alignment optical system ALG is capable of measuring the position of the reference marks on the reference mark plate and the alignment marks on the wafer W in the X,
25 Y two dimensional direction.

The information from the alignment optical system ALG is sent to the alignment control unit (not shown in Figs.). And the alignment control unit digitally converts the

information into a waveform signal, and by processing the signal the position of the mark is detected. The information on the mark position detected, is sent to the main controller 20.

Furthermore, as the alignment optical system ALG, such
5 an alignment sensor that irradiates coherent detection light onto the objective mark and detects the scattered light or the diffracted light generated from the mark, or an alignment sensor that detects the two diffracted lights (such as: even order) generated from the mark by making them interfere, may
10 be used exclusively, or may be combined in use as appropriate. For example, alignment sensors of an LSA (Laser Step Alignment) system, LIA (Laser Interferometric Alignment) system, and the like can be used.

In addition, the exposure system 102 consists of an
15 irradiation optical system 13 and a photodetection optical system 14 that are integrally fixed to the holding member which holds the projection optical system PL, and comprises a focus sensor which measures the position of the wafer W in the Z direction. As the focus sensor (13, 14), a multiple focal
20 position detection system which details are disclosed in, for example, Japanese Patent Laid Open No. 06-283403, and the corresponding U. S. Patent No. 5,448,332, is employed. The output of the focus sensor (13, 14) is sent to the main controller 20, and the main controller 20 sends instructions to the stage
25 control unit 19 to control the Z position and leveling of the wafer holder 25 via the Z leveling table (not shown in Figs.). That is, the main controller 20 performs what is called a focus leveling control. The disclosures referred to above, are fully

incorporated herein by reference.

Furthermore, although it is omitted in Fig. 1, a pair of reticle alignment microscopes are arranged above the reticle R. The details of the reticle alignment microscope, are disclosed in, for example, Japanese Patent Laid Open No. 07-176468, and the corresponding U.S. Patent No. 5,646,413. The reticle alignment microscope disclosed, is structured of the TTR (Through The Reticle) alignment optical system which uses the exposure wavelength to observe the reticle mark (not shown in Figs.) on the reticle R and the mark on the reference plate at the same time via the projection optical system. The detection signals from the reticle alignment microscopes, are sent to the main controller via the alignment control unit (not shown in Figs.).

The main controller 20 is structured of a CPU (Central Processing Unit), a ROM (Read Only Memory), a RAM (Random Access Memory), a microcomputer (or a workstation) including parts such as the I/O interface, and totally controls each parts configuring the exposure system 102.

Along with the main controller 20, an input/output unit 30 is arranged. The input/output unit 30 includes a pointing device such as a mouse or a keyboard, and a display unit. The operator inputs various data through the input/output device 30, and the process program which is a type of database to set exposure conditions is made. This will be referred to later in the description.

The main controller 20 totally controls the synchronous scanning of the reticle R and the wafer W, the stepping operations

of the wafer W, the exposure timing, and the like, so that the exposure operation is performed accurately.

To be more precise, the main controller 20, for example, controls the position of the reticle stage RST and the wafer stage WST based on the measurement values of the laser interferometer 16 and 31 during scanning exposure, while giving out instructions to the stage control system 19 to synchronously move the reticle stage RST and the wafer stage WST. And according to the instructions, the stage control system 19 controls the position and the velocity of the reticle stage RST and the wafer stage WST via the reticle driving portion 11 and the wafer driving portion 21 while monitoring the measurement values of the laser interferometer 16 and 31. By this control, the reticle R is scanned via the reticle stage RST in the +Y direction (or -Y direction) at a velocity $V_r = V$ in respect to the illumination area IAR, and the wafer W is also scanned in synchronous via the wafer stage WST in the -Y direction (or +Y direction) at a velocity $V_w = \beta \cdot V$ (β is the magnification from the reticle R to the wafer W) in respect to the exposure area IA. Thus, in the embodiment, the reticle driving portion 11, the wafer driving portion 21, and the stage control system 19 make up a synchronous driving unit which drives the reticle stage RST and the wafer stage WST in synchronous in a predetermined direction in respect to the exposure light IL, each time exposure is performed.

Also, when the stepping operation is performed, the main controller 20 gives instructions to the stage control system 19 on stepping operations, while controlling the position of

the wafer stage WST based on the measurement values of the laser interferometer 31. And according to the instructions, the stage control system 19 controls the position of the wafer stage WST via the wafer driving portion 21, while monitoring
5 the measurement values of the laser interferometer 31.

In addition, the main controller 20 controls the oscillation wavelength (emission timing) of the light source 1 and the emission power and the like by providing control information to the light source 1 while monitoring the output
10 of the integrator sensor, or controls the light amount irradiated on the reticle R by controlling the rough energy adjuster, so that the target exposure amount which is determined by exposure conditions and the sensitivity of the resist is provided to the wafer W during scanning exposure. Also, the
15 main controller 20 controls the illumination system aperture stop plate, and furthermore, controls the opening and closing of the movable reticle blind 5B in synchronous with the operation information of the stage system.

Next, with the exposure apparatus 100 related to the
20 embodiment, the setting of exposure conditions for making the process program, which is performed prior to exposure, will be briefly described. As an example, the case of setting exposure conditions for double exposure to print isolated lines with an extremely thin line width on the wafer W, will be
25 described. With the double exposure, in the first exposure, a phase shift reticle (hereinafter referred to as "reticle R1" for the sake of convenience), on which fine lines and space (L/S) patterns are formed, is used to perform exposure with

high precision. Next, in the second exposure, a reticle (hereinafter referred to as "reticle R2" for the sake of convenience) on which a pattern is formed that masks the pattern to be transferred (the pattern to be printed onto the wafer),
5 is used for exposure. By using this reticle, the unnecessary portion of the L/S pattern is erased, and only the isolated lines are printed on the wafer. Such details, are disclosed in, for example, Japanese Patent Laid Open No. 04-273427.

First of all, the operator selects "double exposure"
10 on the main menu shown on the display of the input/output unit 30, by using, for example, the mouse. And in correspondence with the selection of double exposure, the main controller 20 shows the screen to determine the name of the reticle used in the double exposure. The operator, then inputs the names
15 of the respective reticles, "R1" and "R2", to be used in the first exposure and in the second exposure through the keyboard. The data of the reticle "R1" and "R2" are respectively stored in the first data storage area and the second data storage area of the RAM.

20 After completing the input of the name of the reticle, when the operator clicks the finish button with the mouse, the main controller 20 then shows the next screen where input is required, such as the setting screen for illumination conditions. The operator then inputs the data of illumination
25 conditions for the first exposure and the second exposure through the keyboard. For example, as the illumination condition for the first exposure and the second exposure, modified illumination and normal illumination are input. The

data input on modified illumination and normal illumination are respectively stored in the first data storage area and the second data storage area of the RAM.

Then, by the operator clicking the finish button with
5 the mouse, the main controller 20 shows the next screen which requires input on the display, and similarly in this manner, input of conditions and the scroll of the screen is repetitively performed. And when all the exposure conditions are input, the process program including the data set on exposure
10 conditions for each exposure is made and filed in the RAM.

The operation on double exposure performed according to the process program will be described next.

As a premise, when starting the exposure operations, preparatory operations in respect to the wafer W such as the
15 loading of the wafer W onto the wafer stage WST and EGA (enhanced global alignment) of the wafer W using the alignment optical system ALG are to be completed beforehand. The details of EGA, are disclosed in, e.g., Japanese Patent Laid Open No. 61-44429 and the corresponding U.S. Patent No. 4,780,617, and the
20 disclosures cited above are fully incorporated herein by reference.

Then, the operator gives instructions through the input/output unit 30 to start exposure, and thus the exposure operation begins.

25 First, the main controller 20 reads the data on exposure conditions (a part of the process program file) stored in the first data storage area of the RAM, and sets the exposure conditions based on the data. In concrete, the reticle R1 is

loaded onto the reticle stage RST via the reticle holder (not shown in Figs.). Also, based on the data read, which is stored in the first data storage area of the RAM, the illumination condition of the first exposure is set along with other exposure
5 conditions. In the conditions set for illumination, selection of the aperture stop on the illumination system aperture stop plate is included. In this case, the aperture stop for modified illumination is to be selected.

Next, the main controller 20 performs reticle alignment
10 in fine mode, as in the following example, based on the data related to exposure accuracy which is also in the data read in the first data storage area of the RAM such as the information on the reticle R1 (to be more specific, that the reticle R1 is a phase shift reticle and the pattern formed is an L/S pattern
15 with an extremely thin line width).

That is, the main controller 20 gives instructions to the stage control system 19 based on the measurement results of the laser interferometer 16 and 31 to move the reticle stage RST and the wafer stage WST, so that out of 4 pairs of reference
20 marks for reticle alignment (hereinafter referred to as "the first reference mark") formed on the reference mark plate on the wafer stage WST, a predetermined pair of the first reference mark and the reticle mark image on the reticle R1 corresponding to the first reference mark can be observed at the same time
25 by using the pair of reticle alignment microscopes (not shown in Figs.).

Then, the main controller 20 measures the amount of positional shift of the reticle mark image on the reticle R1

corresponding to the first reference mark with the pair of reticle alignment microscopes.

The main controller 20 then gives instructions to the stage control system 19, and by synchronously moving the reference mark plate and the reticle R1 by the projection magnification in the Y direction, sequentially measures the amount of positional shift of the reticle mark images corresponding to the remaining three pairs of reference marks.

And from the amount of positional shift of the reticle mark images corresponding to the four pairs of reference marks, the main controller 20 calculates the offset, rotational angle, distortion, and the shift of angle in the scanning direction and the like of the positional shift of the projection image of the reticle R1 in respect to the reference mark plate, or in other words, the wafer stage WST, and stores the calculation results in the temporary storage area of the RAM. The details of the reticle alignment operation are disclosed in, for example, Japanese Patent Laid Open No. 07-176468, and the corresponding U.S. Patent No. 5,646,413, and the disclosures cited above are fully incorporated herein for reference. Then, the main controller 20 corrects the image forming characteristics of the projection optical system PL through the image forming characteristics correction controller so that the distortion referred to above is suppressed to a minimum.

After the reticle alignment described above is completed, the main controller 20 then moves the wafer stage WST so that the reference mark plate is arranged directly below the alignment optical system ALG, and detects the amount of

positional shift of the second reference mark on the reference plate from the detection center of the alignment optical system ALG. And based on the detection results on the positional shift, the measurement values of the laser interferometer 31 at this point, and the designed baseline amount, the main controller calculates what is called the baseline amount.

When the preparatory operations to expose the wafer W is completed in this manner, the main controller 20 then gives instructions to the stage control system 19 to move the wafer stage WST and the reticle stage RST based on the results of the wafer alignment, baseline measurement and the like. The stage control system 19 then controls the wafer driving portion 21 based on the measurement values of the laser interferometer 31, and moves the wafer stage WST to the starting position of scanning exposure of the first shot area on the wafer W. And at the same time, the stage control system 19 controls the reticle driving portion 11 based on the measurement values of the laser interferometer 16, and also moves the reticle stage RST to the starting position of scanning exposure. While this movement is performed by the instructions from the main controller 20, the stage control system 19 also corrects the position of the reticle R1 so that the amount of positional shift of the reticle R1 obtained in the reticle alignment is reduced to a minimum.

Next, based on instructions from the main controller 20, the stage control system 19 begins to scan the reticle stage RST and the wafer stage WST in the Y direction via the driving portions 11 and 21. And when both the stages, RST and

WST respectively reach the target scanning velocity (scanning velocity), and the main controller 20 decides that both the stages RST and WST have reached the synchronous settling state, the ultraviolet pulse light from the light source 1 starts
5 illuminating the pattern area of the reticle R, and thus the scanning exposure begins.

The light source 1 starts to emit the ultraviolet pulse light prior to the scanning exposure, however, since the main controller 20 controls the movement of each blade of the movable
10 reticle blind 5B in synchronous with the movement of the reticle stage RST, the irradiation of the ultraviolet pulse light onto areas other than the pattern area of the reticle R1 is avoided, as is with the scanning stepper in general.

And, different areas of the pattern area of the reticle
15 R1 are sequentially illuminated by the ultraviolet pulse light, and by completing illumination of the entire pattern area, scanning exposure of the first shot area is completed. In this manner, the pattern of the reticle R1 is reduced and transferred onto the first shot area on the wafer W via the projection
20 optical system PL.

During the scanning exposure, in accordance with instructions from the main controller 20, the stage control system 19 corrects the angular error of the reticle R1 in the scanning direction which is obtained during the reticle
25 alignment described earlier.

When the scanning exposure of the first shot area is completed in this manner, based on instructions from the main controller 20, the stage control system 19 then steps the wafer

stage WST to the next shot area via the wafer driving portion 21, and moves the wafer stage WST to the starting position of scanning exposure on the second shot area.

When the stepping is performed, the stage control system 5 19 measures the positional deviation of the wafer stage WST in the X, Y, and θz direction realtime, based on the measurement values of the laser interferometer 31 according to instructions from the main controller 20. And, based on the measurement results, the stage control system 19 controls the wafer driving 10 portion 21 so that the XY positional deviation of the wafer stage WST is set at a predetermined state.

In addition, according to instructions from the main controller 20, the stage control system 19 controls the reticle driving portion 11 based on the information on deviation of 15 the wafer stage WST in the θz direction, and rotatably controls the reticle stage RST so as to compensate for the rotational deviation error on the wafer W side.

And, when the main controller 20 judges that the wafer stage WST has settled to the starting position for scanning 20 exposure on the second shot area, scanning exposure is performed on the second shot area of the wafer W, as is described earlier.

In this manner, scanning exposure and stepping operations to expose the next shot area is repeated, and the pattern of the reticle R1 is sequentially transferred onto the shot areas 25 subject to exposure on the wafer W, and thus the first exposure is completed.

Then, the main controller 20 reads the data on exposure conditions (a part of the process program file) stored in the

second data storage area of the RAM, and sets the exposure conditions based on the data. In concrete, the reticle R2 is loaded onto the reticle stage RST via the reticle holder (not shown in Figs.). Also, based on the data read, which is stored
5 in the second data storage area of the RAM, the illumination condition of the second exposure is set along with other exposure conditions. In the conditions set for illumination, selection of the aperture stop on the illumination system aperture stop plate is included. This time, the aperture stop for normal
10 illumination is to be selected.

Next, the main controller 20 performs reticle alignment in quick mode, which is a mode simplifying the fine mode referred to earlier, based on the data related to exposure accuracy which is also in the data read in the second data storage area
15 of the RAM, such as the information on the reticle R2 (to be more specific, that the reticle R2 is a normal reticle and only a part of the pattern is formed so as to avoid unnecessary patterns from being transferred).

That is, the main controller 20 gives instructions to
20 the stage control system 19 based on the measurement results of the laser interferometer 16 and 31 to move the reticle stage RST and the wafer stage WST via the reticle driving portion 11 and the wafer driving portion 21, so that out of 4 pairs of reference marks for reticle alignment formed on the reference
25 mark plate on the wafer stage WST, a predetermined pair of the first reference mark and the reticle mark image on the reticle R2 corresponding to the first reference mark can be observed at the same time by using the pair of reticle alignment

microscopes (not shown in Figs.).

Then, the main controller 20 measures the amount of positional shift of the reticle mark image corresponding to the first reference mark with the pair of reticle alignment
5 microscopes.

And from the amount of positional shift of the pair of reticle mark images, the main controller 20 calculates the offset and rotational angle of the positional shift of the projection image of the reticle R2 in respect to the reference
10 mark plate, or in other words, the wafer stage WST, and stores the calculation results in the temporary storage area of the RAM. The details of the reticle alignment operation are disclosed in, for example, Japanese Patent Laid Open No. 07-176468, and the corresponding U.S. Patent No. 5,646,413,
15 and the disclosures cited above are fully incorporated herein for reference.

After completing the reticle alignment described above, without performing the baseline measurement, the second exposure is performed using the reticle R2 based on the
20 step-and-scan method, likewise with the first exposure. Thus, the pattern of the reticle 2 is overlaid on all the shot areas on the wafer W subject to exposure that already have the pattern of the reticle R1 accurately transferred.

By the double exposure, the image of isolated lines with
25 an extremely thin line width is formed on each shot area on the wafer W, and by developing the wafer W with the developing unit, the resist image of isolated lines with an extremely thin line width is formed on each shot area on the wafer W.

In the description so far, for the sake of simplicity, the explanation has been omitted, but with the exposure apparatus 100 in the embodiment, in the first exposure and the second exposure, the main controller 20 changes the maximum
5 movement velocity (and acceleration/deceleration velocity) of the wafer stage WST during stepping operations between shots, and the permissible value of positional error when judging the settlement to the set position

More particularly, Fig. 2 schematically shows (a) the
10 temporal change of velocity of the wafer stage WST during stepping operations in the first exposure, and (b) the temporal change of velocity of the wafer stage WST during stepping operations in the second exposure. And Fig. 3(A) corresponds to Fig. 2(a), showing the temporal change of the positional
15 error against the target value after completing deceleration, whereas Fig. 3(B) corresponds to Fig. 2(b) and shows the temporal change of the positional error against the target value after completing deceleration.

As is obvious from Fig. 2, the time itself required for
20 stepping operations is apparently shorter in the second exposure, since the maximum movement velocity (stepping velocity) between shots is faster. Accordingly, by increasing the stepping velocity of the wafer stage WST, the time required to expose the wafer W can be reduced. However, in the case
25 of increasing the stepping velocity, since the wafer stage WST moves faster within a limited distance (the distance in between shots), as can be seen from Fig. 2, the absolute value of the acceleration/deceleration velocity becomes larger. As

a consequence, as is apparent when comparing Fig. 3(A) and Fig. 3(B), vibration caused with position setting becomes greater. Therefore, if the permissible value of the positional error (err) against the target value to judge the settlement
5 of position setting is both the same value, A, then naturally, the time required for the settlement of position setting becomes longer when the stepping velocity is faster.

So, the main controller 20 changes the movement state of the wafer stage WST in the first exposure and second exposure
10 as shown in Fig. 2, based on the data related to the exposure accuracy required such as information on the reticle R1 and information on the reticle R2. Also, the main controller changes the permissible value of the positional error (err) in the second exposure to the value, B, shown in Fig. 3(B).
15 By doing so, as shown in Fig. 3(B), the time required to complete position setting in the second exposure is shortened by T1. Consequently, as can be seen when comparing Fig. 3(A) and Fig. 3(B), the time required for stepping operations in the second exposure can be reduced compared to the first exposure without
20 increasing the settlement time for position setting.

In addition, the main controller 20 changes the movement state (scanning velocity, acceleration/deceleration velocity) of the reticle stage RST and wafer stage WST in the first exposure and the second exposure, based on the data related
25 to the exposure accuracy required such as information on the reticle R1 and information on the reticle R2, likewise as above. As a matter of course, the scanning velocity of the second exposure is faster than the first exposure. By increasing the

scanning velocity, it is obvious that the time required for exposure (scanning exposure time) is reduced.

In this case, as is referred to earlier, modified illumination is employed for the first exposure, whereas, 5 normal illumination is employed for the second exposure. Therefore, the illumination (the intensity of the energy beam irradiated on the wafer W) on the wafer surface (image plane) is stronger in the second exposure. The main controller 20, therefore, sets the scanning velocity during exposure higher 10 in the second exposure in accordance with the illumination variation, so that the desirable exposure amount is provided onto each point on the wafer W at all times.

Also, in the case of increasing the scanning velocity, since the movement strokes of the reticle stage RST are limited 15 the acceleration/deceleration velocity before and after scanning (scanning in this case, is the period of constant synchronous movement) needs to be larger. This also increases the error of the reticle stage RST and wafer stage WST after completing acceleration against the target velocity 20 (accordingly, the error against the target position). And as a consequence, when judging the completion of synchronous settlement based on the same permissible value of the positional error, the time required for both stages RST and WST to reach the constant synchronous state (synchronous settlement time) 25 becomes longer. Therefore, the main controller 20 increases the permissible value of the positional error which determines the synchronous settlement in accordance with the scanning velocity increased, so that the synchronous settlement time

in the second exposure does not increase compared with that of the first exposure.

As is described, with the exposure apparatus 100 related to the embodiment, in the case of performing exposure two times
5 on the same wafer, for example, performing double exposure on each shot area on the wafer W by using the reticle R1 and R2 to print isolated lines with extremely thin line width on the wafer W, the main controller 20 changes: a. the movement state of the wafer stage WST (stepping velocity,
10 acceleration/deceleration velocity) during stepping operations between shots and the permissible value of the positional error (err) against the target value to judge the settlement of position setting to the starting position of scanning on the next shot area; b. the movement state of both
15 the stages WST and RST for exposure (scanning velocity, acceleration/deceleration velocity) and the permissible value of the positional error to determine the synchronous settlement in accordance with the increase in scanning velocity; and c.
20 the setting of fine mode or quick mode in reticle alignment, according to the exposure accuracy (in the embodiment, the exposure accuracy is judged, for example, based on the information on the reticle R1 and R2) required in each exposure. In this case, the main controller 20 changes each control factor so that in the first exposure where high exposure accuracy
25 is required, more importance is put on resolution rather than throughput, and on the other hand, in the case where the exposure accuracy required is not so high, then the priority is on throughput rather than resolution.

By changing the movement state of the wafer stage WST (stepping velocity, acceleration/deceleration velocity) during stepping operations between shots and the permissible value of the positional error (err) against the target value to judge the settlement of position setting to the starting position of scanning on the next shot area, as is described above in a., the time required for stepping operations can be reduced in the second exposure when compared with the first exposure without increasing the settlement time for position setting, as is described earlier. Therefore, as a consequence, the time required for exposure can be reduced.

However, this does not always have to be executed. If the velocity and acceleration/deceleration velocity (the movement state) of the wafer stage WST during stepping operations is changed in consideration of reducing the exposure time by increasing the stepping velocity and the increase in settlement time of position setting, to an extent so that the throughput increases in general, the same value may be used at all times as the permissible value of the positional error (err) against the target value to judge the settlement of position setting.

Or, in the first exposure and the second exposure, only the permissible value of the positional error on position setting may be changed, without changing the velocity and acceleration/deceleration velocity (the movement state) of the wafer stage WST during stepping operations. When the permissible value of the positional error is increased, the position setting state can be defined at an earlier stage,

which in turn pulls up the start of the next operation (such as the scanning operations of the reticle stage RST and wafer stage WST on exposure), thus making it possible to reduce the total exposure time.

5 In addition, by changing the movement state of both the stages WST and RST for exposure (scanning velocity, acceleration/deceleration velocity) and the permissible value of the positional error to determine the synchronous settlement in accordance with the increase in scanning velocity, as is
10 stated above in b., when the scanning velocity in the second exposure is increased compared with the first exposure, the time required for scanning exposure can be reduced without increasing the settlement time for position setting, as is described earlier.

15 However, regardless of what is described above, if the movement state of both the stages WST and RST during scanning (velocity, acceleration/deceleration velocity) is changed in consideration of reducing the scanning exposure time by increasing the scanning velocity and the increase in the
20 synchronous settlement time, to an extent so that the throughput increases in general, the same value may be used at all times as the permissible value of the positional error to judge the synchronous settlement.

 Alternatively, the permissible value of the positional
25 error to judge the synchronous settlement of both stages may be increased, without changing the scanning velocity and the like of the reticle stage RST and wafer stage WST. In this case, since both stages reach the synchronous settling state

at an earlier stage, the next exposure operation (irradiation of the exposure light IL) can start earlier, thus making it possible to reduce the total exposure time.

By changing the reticle alignment mode, as is stated
5 above in c., the time required for reticle alignment in the second exposure is apparently reduced compared with the first exposure, allowing improvement in throughput compared with the case when the fine mode reticle alignment is performed in each exposure. The reticle alignment is performed to align
10 the position (overlay) between the reticle and the wafer, therefore, in the embodiment, the main controller 20 consequently changes the relative alignment precision between the reticle pattern and the wafer on exposure, by changing the mode of reticle alignment.

15 With the exposure apparatus 100 according to the embodiment, the main controller 20 changes various throughput control factors such as a. - c. described above in accordance with the exposure accuracy required. Therefore, when performing double exposure on the same wafer, compared with
20 the case when the exposure system 102 is controlled based on the same throughput control factor on each exposure, it is obvious that the throughput can be improved. Meanwhile, since the throughput factor is changed in the second exposure where the exposure accuracy required is not so high, that is, the
25 throughput factor is changed so that priority is put on throughput only when a decrease in exposure accuracy is allowed to some extent, as a consequence, the exposure accuracy can be maintained at a sufficient level. Furthermore, of the

throughput control factors a. to c., for example, the factor c. does not necessarily have to be performed. That is, in the first exposure and the second exposure, only at least one throughput control factor, which is related to the exposure
5 operation other than alignment, needs to be changed.

Furthermore, in the description so far, the case has been described of performing double exposure to print a pattern of isolated lines with an extremely thin line width on the wafer W. The present invention, however, is not limited to
10 this, and similarly, in the case of double exposure with the first exposure to set the pattern size and the second exposure to set the shape of the pattern, the throughput can be improved while maintaining sufficient exposure accuracy with the exposure apparatus 100 in the embodiment, likewise with the
15 case described earlier.

As other examples of the double exposure method, there is an exposure method of using longer L/S or isolated lines than that of the designed value (the final pattern to be printed) as the first pattern, and when transferring the first pattern
20 using modified illumination or the phase shift reticle to improve the resolution and depth of focus (DOF) in the first exposure, whereas in the second exposure as the second pattern a frame shaped pattern corresponding to each line pattern is transferred under the condition of normal illumination so as
25 to remove both ends of the line pattern that grow thinner. Such an exposure method, is disclosed in, for example, Japanese Patent Laid Open No. 10-284377, and the corresponding U.S. Application No. 055,949 (application filed: April 7, 1998),

and the disclosures cited above are fully incorporated herein by reference.

As other examples, there is the optical proximity correction (OPC) to print a small, squarish-shaped pattern onto the wafer, which details are disclosed in, Japanese Patent Laid Open No. 02-166717. With the OPC, not only the pattern required, but also the unnecessary patterns are printed in the first exposure. And, the second exposure is performed to remove the unnecessary patterns, however, in the second exposure, the exposure accuracy required is not so tight as the first exposure. Accordingly, by changing the throughput control factor (changing the control accuracy) in accordance with the exposure accuracy required likewise as above, the time required for the second exposure is reduced, making it possible to improve the throughput.

Furthermore, in the embodiment, the case has been described of double exposure on the same wafer. The method of changing the throughput control factor (changing the control accuracy) in accordance with the exposure accuracy required, however, can be applied as a matter of course, to multiple exposure such as triple exposure and over.

In the description so far, the case has been described in which the present invention is applied to multiple exposure such as double exposure. If the exposure accuracy required in each exposure differs, however, the present invention can be applied to joint exposure (stitching exposure) where patterns are transferred on adjacent divided areas on the same wafer (substrate) so that the patterns are joined on the wafer.

In addition, if the exposure accuracy required each time (or in each layer) differs, the first exposure and the second exposure may be performed on the same wafer (substrate) but on different layers. In this case, as is described above, the first exposure may be to set the pattern size and the second exposure may be to set the shape of the pattern. In such a case, the control accuracy on the second exposure (the accuracy changed by changing the throughput control factor as in a. - c. when described in line with the embodiment) can be loosely set compared with the control accuracy of the first exposure. By doing so, the throughput can be improved while sufficiently maintaining the exposure accuracy, likewise with the embodiment.

For example, in the case of performing exposure on different layers on the same wafer, the main controller 20 can change either the movement state of the wafer stage WST (stepping velocity, acceleration/deceleration velocity) during stepping operations between shots or the permissible value of the positional error on position setting, the movement state of the reticle stage RST and wafer stage WST on scanning exposure (scanning velocity, acceleration/deceleration velocity) and either one of the corresponding illumination on the wafer surface and the permissible value of the positional error to determine the synchronous settlement, or the reticle alignment mode, or all of these three according to the exposure accuracy required in each layer. Alternatively, or in addition to these, the main controller 20 may change the number of the sample shots or the number of the sample marks in the EGA which

is performed prior to each exposure, from the second exposure onward according to the exposure accuracy required. In this case, when the exposure accuracy required is high, then the number of the EGA sample shots is increased, and in the case
5 the required exposure accuracy is not so high, then the number of the EGA sample shots is reduced. This allows an increase in throughput compared with when the same number of sample shots are used regardless of the exposure accuracy required. Also, the exposure accuracy can be sufficiently maintained.
10 In this case, needless to say, the relative alignment precision between the reticle and the wafer is changed by changing the number of EGA sample shots. In addition, a plurality of wafer alignment modes (including modes such as an EGA mode, and a weighted EGA mode which provides weight to the positional
15 information corresponding to the distance between the shot which coordinate value has to be obtained and each sample shot) can be used, and the mode may be changed in accordance with the exposure accuracy.

Alternate to, or in addition to what has been described,
20 the main controller 20 may change at least one of the permissible value of the energy dispersion of the pulse light emitted from the light source 1 and irradiated on the wafer W and the repetition frequency on each exposure as the throughput control factor, according to the exposure accuracy required. If the
25 permissible value of the energy intensity dispersion of the pulse light is large, then the time required for adjustment can be reduced. And if the repetition frequency is high, the energy power also increases, therefore re-measurement of the

light amount is required. However, if the exposure accuracy required is loose enough, then the re-measurement may be omitted. Accordingly, by omitting the re-measurement and by the energy power increased with the increase of the repetition frequency
5 (in the case of the scanning exposure apparatus, the scanning velocity needs to be adjusted according to this increase), the time required for exposure can be reduced.

Furthermore, in the embodiment above, the case has been described when the main controller 20 changes the throughput control factor on its own judgement, according to the exposure
10 accuracy required each time exposure is performed, however, the present invention is not limited to this. For example, in the case the control system has a process program file that sets various parameters to control the exposure system, similar
15 to the embodiment above, the process program file may be made so that the various parameter values related to the control factors used in each exposure can be individually set. In such a case, the operator individually sets the various parameter values used in each exposure in the process program file in
20 advance, and the control system controls the exposure system in accordance with the process program file. Thus, the control factor is changed on each exposure, according to the exposure accuracy required. Therefore, only a minor change in the current process program file is needed, and there is no need
25 to make a new, complex exposure processing program (software).

In addition, in the embodiment above, the case has been described of the present invention being applied to the scanning exposure apparatus based on the step-and-scan method. Th

present invention, however, is not limited to this, and is suitably applicable to a static type exposure apparatus such as the stepper. In the case of the stepper, as the control system, instead of the throughput control factor (excluding
5 the factors related to scanning) which has been described, or in addition to it, the permissible value of defocus on exposure may be changed.

For example, when the required exposure accuracy is tight, the defocus amount allowed is extremely small, and if the
10 exposure accuracy required is loose, then even if the permissible defocus amount may be a little large, it hardly affects the exposure. Accordingly, the control system sets a small permissible value for defocus when the exposure accuracy required is high, and sets a somewhat large permissible value
15 for defocus when the exposure accuracy required is not so high. As a consequence, compared to the former, the latter requires less time for pre-focusing to bring the focus up to a proximate level, and compared with the case of setting the same permissible value for defocus on exposure regardless of the exposure
20 accuracy required, the time required for exposure can be reduced. In this case, the exposure accuracy can be sufficiently maintained.

In addition, in the case of the stepper, an alignment method may be employed, in which the magnification and rotation
25 and the like of the reticle are obtained via the projection optical system by using a method similar to EGA on the reticle (mask) side. The details of this method are disclosed in, for example, Japanese Patent Laid Open No. 07-122473, and the

corresponding U.S. Application No. 240,599 (application filed: February 1, 1999). And by changing the number of the sample marks of the EGA in accordance with the exposure accuracy required, the relative alignment precision between the mask and the substrate may be changed. The disclosures referred to above, are fully incorporated herein by reference.

Also, in the case of the stepper, if the intensity of the energy beam irradiated on the substrate (illumination on the substrate) is stronger, the time required to expose the substrate can be reduced, and by reducing the exposure time the throughput can be improved. When changing the illumination on the substrate, in the case the energy beam source is a pulse laser light source the repetition frequency may be increased, or the energy amount per pulse from the energy beam source may be increased. Or, the attenuation ratio of the attenuation element along the optical path between the energy beam source and the substrate may be changed.

In addition, the present invention can be applied to an X-ray exposure apparatus based on the proximity method, and the like, that does not use the projection optical system.

Furthermore, in the embodiment above, the case has been described in which the present invention is applied to the exposure apparatus using the ArF excimer laser beam (wavelength: 193nm) or the F₂ laser beam (wavelength: 157nm) and the like as the exposure light IL. The present invention, however, is not limited to this, and can be suitably applied to an exposure apparatus using vacuum ultraviolet light such as the Kr₂ laser beam (wavelength: 146nm), Ar₂ laser beam

(wavelength: 126nm) and the like, or an exposure apparatus using EUV light in the soft X-ray region (wavelength: 5-30nm).

In addition, with the present invention, as the energy beam a harmonic may be used. This harmonic, is obtained by amplifying a single-wavelength laser beam in the infrared or visible range being emitted by a DFB semiconductor laser or fiber laser with a fiber amplifier doped with erbium (or both erbium and ytterbium), and converting the wavelength into ultraviolet light using a nonlinear optical crystal.

10 If, for example, the oscillation wavelength of a single-wavelength laser is set within the range of 1.51 to 1.59 μm , an eighth-harmonics whose generation wavelength falls within the range of 189 to 199 nm or a tenth-harmonics whose generation wavelength falls within the range of 151 to 159
15 nm is output. If the oscillation wavelength is set in the range of 1.544 to 1.553 μm , in particular, an eighth-harmonics whose generation wavelength falls within the range of 193 to 194 nm, that is, ultraviolet light having almost the same wavelength as that of an ArF excimer laser beam, can be obtained. If the
20 oscillation wavelength is set within the range of 1.57 to 1.58 μm , a tenth-harmonics whose generation wavelength falls within the range of 157 to 158 nm, that is, ultraviolet light having almost the same wavelength as that of an F₂ laser beam, can be obtained.

25 If the oscillation wavelength is set within the range of 1.03 to 1.12 μm , a seventh-harmonics whose generation wavelength falls within the range of 147 to 160 nm is output. If the oscillation wavelength is set within the range of 1.099

to 1.106 μm , in particular, a seventh-harmonics whose generation wavelength falls within the range of 157 to 158 μm , that is, ultraviolet light having almost the same wavelength as that of an F_2 laser beam, can be obtained. In this case, as a single-wavelength oscillation laser, for example, an ytterbium-doped fiber laser can be used.

Furthermore, the projection optical system or the illumination optical system referred to in the embodiment, is a mere example, and it is a matter of course that the present invention is not limited to this. For example, the projection optical system is not limited to the refraction optical system, and a reflection system made up of only reflection optical elements, or a reflection/refraction system (catadioptric system) comprising reflection optical elements and refraction optical elements may be employed.

Furthermore, the present invention can be applied to not only an exposure apparatus manufacturing a semiconductor element but also to an exposure apparatus to transfer a device pattern onto a glass plate used to manufacture a display such as a liquid crystal display, to transfer a device pattern onto a ceramic wafer used to manufacture thin-film magnetic heads, an exposure apparatus used to manufacture image sensing devices (CCDs and the like), an exposure apparatus used to manufacture a micromachine and DNA chips, and in addition, an exposure apparatus used to manufacture a mask or a reticle.

The exposure apparatus 100 in the embodiment above related to the present invention can be made by incorporating the illumination optical system made up of a plurality of lenses

and the projection optical system into the main body of the exposure apparatus, performing optical adjustment, while incorporating the reticle stage or wafer stage that are made up of various mechanical components into the main body of the exposure apparatus, and connecting the wiring and piping, and furthermore, performing total adjustment (electrical adjustment, operational adjustment). The exposure apparatus is preferably made in a clean room in which temperature, degree of cleanliness, and the like are controlled.

10 - Device Manufacturing Method

A device manufacturing method using the exposure apparatus 100 and the exposure method described above in a lithographic process, will be described next.

Fig. 4 is a flow chart showing an example of manufacturing a device (a semiconductor chip such as an IC or LSI, a liquid crystal panel, a CCD, a thin magnetic head, a micromachine, or the like). As shown in Fig. 4, in step 201 (design step), function/performance is designed for a device (e.g., circuit design for a semiconductor device) and a pattern to implement the function is designed. In step 202 (mask manufacturing step), a mask on which the designed circuit pattern is formed is manufactured. In step 203 (wafer manufacturing step), a wafer is manufacturing by using a silicon material or the like.

In step 204 (wafer processing step), an actual circuit and the like is formed on the wafer by lithography or the like using the mask and wafer prepared in steps 201 to 203, as will be described later. In step 205 (device assembly step), a device is assembled using the wafer processed in step 204.

Step 205 includes processes such as dicing, bonding, and packaging (chip encapsulation).

Finally, in step 206 (inspection step), a test on the operation of the device, durability test, and the like are performed. After these steps, the device is completed and shipped out.

Fig. 5 is a flow chart showing a detailed example of step 204 described above in manufacturing the semiconductor device. Referring to Fig. 5, in step 211 (oxidation step), the surface of the wafer is oxidized. In step 212 (CVD step), an insulating film is formed on the wafer surface. In step 213 (electrode formation step), an electrode is formed on the wafer by vapor deposition. In step 214 (ion implantation step), ions are implanted into the wafer. Steps 211 to 214 described above constitute a pre-process for the respective steps in the wafer process and are selectively executed in accordance with the processing required in the respective steps.

When the above pre-process is completed in the respective steps in the wafer process, a post-process is executed as follows. In this post-process, first, in step 215 (resist formation step), the wafer is coated with a photosensitive agent. Next, as in step 216, the circuit pattern on the mask is transcribed onto the wafer by the above exposure apparatus and method. Then, in step 217 (developing step), the exposed wafer is developed. In step 218 (etching step), an exposed member on a portion other than a portion where the resist is left is removed by etching. Finally, in step 219 (resist removing step), the unnecessary resist after the etching is removed.

By repeatedly performing these pre-process and post-process steps, multiple circuit patterns are formed on the wafer.

As described above, according to the device manufacturing method of this embodiment, the exposure apparatus and the exposure method in the embodiment is used in the exposure process (step 216). Therefore, exposure is performed with the throughput improved, while sufficiently maintaining the exposure accuracy. Accordingly, the throughput can be improved without reducing the yield of the microdevice on which a fine pattern is formed, and as a consequence, the productivity is improved.

While the above-described embodiments of the present invention are the presently preferred embodiments thereof, those skilled in the art of lithography systems will readily recognize that numerous additions, modifications, and substitutions may be made to the above-described embodiments without departing from the spirit and scope thereof. It is intended that all such modifications, additions, and substitutions fall within the scope of the present invention, which is best defined by the claims appended below.

**WHAT IS CLAIMED IS:**

1. An exposure method which performs exposure on a substrate at least twice, said exposure method comprising:
 - 5 performing a first exposure on said substrate with a first control accuracy which corresponds to a first exposure accuracy required; and
 - performing a second exposure on said substrate with a second control accuracy which corresponds to a second exposure accuracy different from said first exposure accuracy required.
- 10 2. The exposure method according to Claim 1, wherein said first exposure and said second exposure are exposure on different layers on said substrate.
- 15 3. The exposure method according to Claim 1, wherein said first exposure and said second exposure are exposure on a same layer on said substrate.
- 20 4. The exposure method according to Claim 3, wherein said first exposure and said second exposure are a stitching exposure on which patterns are transferred onto adjacent divided areas on said substrate so that said patterns are joined on said substrate.
- 25 5. The exposure method according to Claim 3, wherein said first exposure and said second exposure are a multiple exposure on which patterns are overlaid and transferred onto



a same area on said substrate.

6. The exposure method according to Claim 1, wherein
said first exposure is an exposure which is performed
5 on said substrate to set a pattern size, and
said second exposure is an exposure which is performed
on said substrate to set a shape of said pattern.

7. The exposure method according to Claim 6, wherein
10 said second control accuracy is set looser than said first
control accuracy.

8. The exposure method according to Claim 6, wherein
said first exposure and said second exposure are exposure on
15 different layers on said substrate.

9. The exposure method according to Claim 6, wherein
said first exposure and said second exposure are exposure on
a same layer on said substrate.

20

10. The exposure method according to Claim 6, wherein
said first exposure and said second exposure are a stitching
exposure on which patterns are transferred onto adjacent
divided areas on said substrate so that said patterns are joined
25 on said substrate.

11. The exposure method according to Claim 6, wherein
said first exposure and said second exposure are a multiple



exposure on which patterns are overlaid and transferred onto a same area on said substrate.

12. The exposure method according to Claim 1, wherein
5 said control accuracy includes at least one of a movement state of said substrate when position setting a plurality of divided areas on said substrate to predetermined reference positions, a permissible value of positional error on said position setting, a relative alignment precision between said substrate and a
10 mask on which a pattern to be transferred onto said substrate is formed, a movement state when said mask and said substrate is moved in synchronous in a predetermined direction, and a permissible value to determine a settlement when said mask and said substrate is moved in synchronous.

15

13. An exposure apparatus comprising:

an exposure system which irradiates an energy beam onto a mask on which a pattern is formed and transfers said pattern onto a substrate held on a substrate stage; and

20 a control system which totally controls said exposure system and changes a control factor of said exposure system contributing to throughput, in accordance with the exposure accuracy required in each exposure when repetitively performing exposure at least twice on said substrate.

25

14. The exposure apparatus according to Claim 13, wherein said control system changes said control factor of said exposure system contributing to throughput, in accordance



with the exposure accuracy required in each layer when performing exposure on different layers on said substrate.

15. The exposure apparatus according to Claim 13,
5 wherein said control system changes said control factor of said exposure system contributing to throughput, in accordance with the exposure accuracy required in each exposure when performing exposure at least twice on a same layer on said substrate.

10

16. The exposure apparatus according to Claim 15,
wherein said control system controls said exposure system and performs a stitching exposure on which patterns are transferred onto adjacent divided areas on said substrate so that said
15 patterns are joined on said substrate, as exposure performed at least twice on said same layer on said substrate.

17. The exposure apparatus according to Claim 15,
wherein said control system controls said exposure system and
20 performs a multiple exposure on which patterns are overlaid and transferred onto a same area on said substrate, as exposure performed at least twice on said same layer on said substrate.

18. The exposure apparatus according to Claim 17,
25 wherein said control system controls said exposure system for said multiple exposure, which includes at least a first exposure to set a pattern size and a second exposure to set a shape of said pattern on said substrate.



19. The exposure apparatus according to Claim 13, wherein said control factor changed by said control system includes at least one of

- 5 a movement state of said substrate stage when position setting sequentially a plurality of divided areas on said substrate to predetermined reference positions, and
- a permissible value of positional error on said position setting.

10

20. The exposure apparatus according to Claim 13, wherein said exposure system comprises a projection optical system which projects said energy beam outgoing from said mask onto said substrate, and said control factor changed by said

15 control system includes a permissible value of defocus on said each exposure.

21. The exposure apparatus according to Claim 13, wherein said exposure system comprises a pulse laser light

20 source as an energy beam source which emits said energy beam, and said control factor changed by said control system includes at least one of an energy intensity and a repetition frequency of a pulse light irradiated on said substrate emitted from said pulse laser light source on said each exposure.

25

22. The exposure apparatus according to Claim 13, wherein said control factor changed by said control system includes a relative alignment precision between said pattern



of said mask and said substrate.

23. The exposure apparatus according to Claim 22,
wherein said control factor changed by said control system
5 is an alignment mode of at least one of said mask and said
substrate.

24. The exposure apparatus according to Claim 22,
wherein said control factor changed by said control system
10 is at least one of a number of sample shots and a number of
sample marks on alignment of said substrate.

25. The exposure apparatus according to Claim 22,
wherein said control factor changed by said control system
15 is a number of sample marks on alignment of said mask.

26. The exposure apparatus according to Claim 13,
wherein said exposure system comprises:

a mask stage which holds said mask; and
20 a synchronous driving unit which drives said mask stage
and said substrate stage in synchronous in a predetermined
direction in respect to said energy beam on said each exposure,
and

said control factor changed by said control system
25 includes at least one of

a movement state of said mask stage and said
substrate stage and an intensity of said energy beam
corresponding to said movement state irradiated on said



substrate, and

a permissible value of positional error to determine synchronous settlement of said mask stage and said substrate stage on said each exposure.

5

27. The exposure apparatus according to Claim 13, wherein said control system has a process program file to set various parameters to control said exposure system, and parameter values for said each exposure can be set individually
10 in said process program file.

28. A device manufacturing method including a lithographic process, wherein exposure is performed by using said exposure method according to Claim 1.

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29. A device manufacturing method including a lithographic process, wherein exposure is performed by using said exposure apparatus according to Claim 13.

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