

DESCRIPTION

A METHOD OF CONTROLLING A STAGE, A STAGE UTILIZING
THEREOF AND AN EXPOSURE APPARATUS UTILIZING THEREOF
OF SYNCHRONOUS STAGES

5 TECHNICAL FIELD

The present invention relates to a method of
controlling a high-precision positioning system. More
particularly, the present invention relates to
achieving a desired magnification and orthogonality in
10 a scanning microlithographic system, a stage utilizing
thereof and an exposure apparatus utilizing thereof.

BACKGROUND ART

High-precision positioning systems, such as those
used in machining tools or lithography, drive
15 components of the system in accordance with a defined
path within narrow tolerances. The path may have one
direction, e.g., the K coordinate, or two directions,
e.g., the X and, orthogonal Y coordinates. Typically in
a scanning microlithography apparatus for semiconductor
20 wafer processing, a stage is used to position a mask
(reticle) in two dimensions, while a separate stage is
used to position the plate (wafer) The stages are both
carried upon a first stage *that* moves at a constant
velocity during exposure of the plate. The entire
25 system is supported by a base structure along with
other components such as a source of radiant energy and

a projection lens to focus the energy.

Figs. 1 and 2 show a respective front view and perspective view of a simplified scanning microlithographic positioning table mechanism 10. Table mechanism 10 includes a coarse stage 12; a mask fine stage 14, which holds a mask (reticle) 15; and a plate fine stage 16, which holds a plate (wafer) 17. Fig. 1 also shows a projection lens 18 and an illumination apparatus 20, which produces a light beam 21 for exposing plate 17. Coarse stage 12 is supported by a base structure (not shown) containing an antivibration device and anti-friction bearings, such as air bearings or roller bearings, as is well known in the art. Coarse stage 12 is conventionally driven at a constant velocity in the K coordinate direction, as illustrated by arrow 13 in Fig. 2, during exposure of plate 17. Illumination apparatus 20 and projection lens 18 remain relatively stationary.

Mask fine stage 14 and plate fine stage 16, which are attached to coarse stage 12, move at the same velocity during exposure of plate 17. Thus, in theory table mechanism 10 has a magnification of 1:1, i.e., the area of mask 15 that is scanned across illumination apparatus 20 is equal to the area of plate that is exposed. Additionally, because mask fine stage 14 and plate fine stage 16 are attached to coarse stage 12 and

move at the same velocity, the magnification factor and orthogonality factor of table mechanism 10 are fixed.

In practice, however, there may be error in the magnification caused by projection lens 18 or
5 synchronous error caused by the motion of coarse stage 12. Additionally, the projection lens 18 and synchronous error may create error in the orthogonality of the exposed image. Orthogonality error results in the image from mask 15 being reproduced on plate 17 in
10 a skewed manner (an example of orthogonality error is shown in Fig. 8B). These errors result in poor quality and low resolution of the exposed image. Thus, it is advantageous to correct magnification and orthogonality error in the positioning system or change the
15 magnification factor or orthogonality factor to a desired value.

DISCLOSURE OF THE INVENTION

A scanning positioning system in accordance with the present invention moves one fine stage relative to
20 the another fine stage to correct magnification and orthogonality error or to change the magnification or orthogonality factors to a desired level. A scanning position system, such as a micro lithographic system, has a mask fine stage and a plate fine stage mounted on
25 a coarse stage that moves at a constant velocity during the exposure of the plate. The position of one fine

stage is measured relative to the other fine stage.
With this position information, one of the fine stages
may be moved by an appropriate amount in the same or
opposite direction of the scan to increase or decrease
5 the magnification. Thus, the scanning position system
can change the magnification factor to a desired level,
as well as correct any magnification error or any
rotation error. Likewise, by moving one of the fine
stages by an appropriate amount in a direction
10 perpendicular to the scan, the system can change the
orthogorality factor by a desired amount, as well as
correct any orthogonality error.

It is one object of the present invention to
provide a method comprising: starting a scan of a first
15 stage along a first coordinate, wherein said first
stage carries a second stage and a third stage;
measuring a position of said second stage in said
first coordinate and in a second coordinate relative to
said third stage; and moving said second stage along
20 said first coordinate relative to said third stage at a
first velocity proportional to a desired magnification
factor.

It is further object of the present invention to
provide a scanning apparatus, comprising: a first stage
25 moving along a first coordinate; a second stage movably
mounted to said first stage; a third stage mounted to





said first stage; a mechanism for moving said second stage along said first coordinate relative to said third stage at a first velocity proportional to a magnification factor; and

5 a position control circuit, said position control circuit controls said mechanism for moving said second stage along said first coordinate.

It is further object of the present invention to provide An exposure apparatus for projecting a pattern
10 of a mask on a substrate, said apparatus comprising: a first stage which moves said mask; a second stage which moves said substrate; a third stage connected to either one of said first and second stages; and a driver which drives said third stage prior to the start of said
15 projection.

In one embodiment of the present invention, the mask fine stage has a mask frame attached to the coarse stage. A mask holder is attached to the mask frame via actuators that move the mask holder relative to the
20 mask frame and the coarse stage. A position control apparatus receives information regarding the position of the mask fine stage relative to the plate fine stage. Based on this position information, the position control apparatus sends commands to the actuators to
25 move the mask holder relative to the plate fine stage by an amount necessary to achieve the desired

magnification and orthogonality. The position control apparatus can also be used to simultaneously compensate for any synchronous error between the fine stages and reduce the settling time of the system.

5 **BRIEF DESCRIPTION OF THE DRAWINGS**

Fig. 1 shows a front view of a simplified scanning microlithographic positioning table mechanism.

Fig. 2 shows a perspective view of a simplified scanning microlithographic positioning table mechanism.

10 Fig. 3 shows a perspective view of a scanning microlithographic system including a position control apparatus in accordance with the present invention.

15 Figs. 4A, 4B, 4C show the beginning, middle and end, respectively, of the exposure of a plate on the plate fine stage during the scanning process.

Fig. 4D illustrates the change of magnification in accordance with the present invention.

20 Figs. 5A, 5B, and 5C illustrate the respective magnification and orthogonality changes of an exposed image on a plate.

Fig. 6 shows a side view of a mask fine stage, including a mask frame and mask holder with actuators disposed between, in accordance with one embodiment of the present invention.

25 Fig. 7 shows a close up side view of an actuator disposed between the mask frame and mask holder.

Figs. 8A, 8B, 8C, and 8D are graphic representations of the respective acceleration, velocity of the coarse stage, velocity of the fine stage, and position in the X coordinate of the coarse stage in relation to time during a scan.

Fig. 9 shows a top view of coarse stage carrying a pre-positioned mask and plate in relation to the beginning exposure point.

Fig. 10 shows a structure of an another embodiment of a scanning type exposure apparatus according to the present invention.

BEST MODE FOR CARRING OUT THE INVENTION

Fig. 3 shows a simplified perspective view of a scanning microlithographic system 100 in accordance with the present invention. Microlithographic system 100 includes a coarse stage 102 that carries a mask fine stage 104 and a plate fine stage 106. Plate fine stage 106 holds a plate (wafer) 107, while mask fine stage 104 holds a mask (reticle) 120. System 100 also includes a position control apparatus 108, such as a digital signal processor or micro-processor. Although the present invention is described with reference to a scanning microlithographic system, it is understood that the present invention applies to other high-precision positioning systems as well. Conventional details of stages 102, 104, and 106 are not shown.

For information relating to the workings of an exemplary suitable position control apparatus, see the co-pending application entitled "POSITION CONTROL APPARATUS FOR FINE STAGES CARRIED BY A COARSE STAGE ON
5 A HIGH- PRECISION SCANNING POSITIONING SYSTEM," by Bausan Yuan, and Kazuaki Saiki, application serial number 09/045,218 the contents of which are incorporated herein by reference. Other conventional position control apparatuses may also be used.

10 During scanning, coarse stage 102 moves along in the Y coordinate direction, as indicated by arrow 103. Position control apparatus 108 controls the movement of coarse stage 102 by updating the desired position for coarse stage 102 over many cycles during the scan. It
15 will be appreciated that position control apparatus 108 may also control the movement of coarse stage 102 through other methods such as controlling the velocity or acceleration of coarse stage 102.

The position control apparatus 108 also controls
20 movement of mask 120 on mask fine stage 104 during scanning, such that mask 120 moves along both the K and Y coordinate directions relative to plate 107, as illustrated by arrows 105. Position control apparatus 108 controls the movement of mask 120 by updating the
25 desired position for mask 120 at each cycle during the scan or y controlling the velocity of mask 120.

Position control apparatus 108 produces a change in the magnification or orthogonality of the exposed image on plate 107 on plate fine stage 106 by moving mask 120 relative to plate 107 such that mask 120 has a velocity proportional to a magnification factor or orthogonality factor. By moving mask 120 relative to plate 107, position control apparatus 108 can increase or decrease the magnification and orthogonality when desired, as well as compensate for any error in the magnification or orthogonality of microlithography system 100 caused by the projection lens or synchronous error.

During exposure, coarse stage 102 moves along the K coordinate at a constant velocity. To increase or decrease magnification, position control apparatus 108 moves mask 120 in the K coordinate direction at a velocity proportional to the magnification factor. Thus, if a magnification factor of 1.1 to 1 is desired, mask 120 is moved relative to plate 107 at 0.1 times the speed of coarse stage 102.

Figs. 4A, 4B, and 4C show the respective beginning, middle and end of a scan in the K coordinate direction while plate 107 on plate stage 106 is being exposed. Position control apparatus 108 shown in Fig. 3, moves coarse stage 102 across a conventional illumination source 111 and projection lens 109, as indicated by arrow 103, such that coarse stage 102 has a constant

velocity V_c relative to illumination source 111 and projection lens 109. As shown in Fig. 4A, when fine stages 104, 106 are at the beginning exposure point, mask fine stage 104, which is carrying mask 120, is moved by position control apparatus 108, as indicated by arrow 105, such that mask fine stage 104 moves at a predetermined velocity V_m in the K coordinate direction. The predetermined velocity V_m of mask fine stage 104 is relative to plate fine stage 106. Plate fine stage 106 does not move relative to coarse stage 102 in this embodiment, however, it is understood that plate fine stage 106 may move relative to coarse stage 102 if mask fine stage 104 maintains a velocity V_m relative to plate fine stage 106. Position control apparatus continues to move mask fine stage 104 at velocity V_m relative to plate fine stage 106 until reaching the end of the scan, shown in Fig. 4C.

Although the entire mask fine stage 104 is shown moving relative to plate fine stage 106 in Figs 4A-4C, one skilled in the art will appreciate that the magnification and orthogonality correction is achieved through the motion of mask 120 relative to plate 107. Accordingly, it is understood that mask fine stage 104 may remain stationary relative to coarse stage 102, while mask 120 is moved at a velocity V_m relative to plate 107.

Fig. 4D illustrates the length of mask fine stage 104 that was scanned in front of illumination source 111 (not shown in Fig. 4D) with respect to the length of plate fine stage 106 that was exposed by illumination source 111 during the scan. Thus, Fig. 4D illustrates the magnification achieved by mask fine stage 104 maintaining a velocity V_m relative to plate fine stage 106 during exposure. This magnification can also be seen in Fig. 8A, which illustrates the transfer of the pattern on mask 120 to plate 107. As illustrated, the exposed image on plate 107 is smaller than the unmagnified image (shown with dashed lines) that would have been exposed if there was no change in the magnification factor.

Orthogonality of the exposed image may be controlled by moving mask 120 at a velocity proportional to the orthogonality factor in the Y coordinate direction (perpendicular to the scanning direction of coarse stage 102) during exposure of plate 07. The orthogonality correction can be seen in Fig. 5B, which illustrates the transfer of the pattern on mask 120 to plate 107. As illustrated, the exposed image on plate 107 has no orthogonal error in contrast with the image (shown with dashed lines) that would have been exposed if there was no orthogonality correction.

In addition, rotation error may be corrected by

rotating mask 120 by an appropriate amount during the scan. Fig. 8C illustrates the correction of rotation error on plate 107. The image that would have been exposed on plate 107 without correction of the rotation error is shown with dashed lines. Rotation error occurs due to thermal stress (distortion) generated during the exposure of plate 107. Thus, position control apparatus 108, shown in Fig. 3, may control actuators 114, 116, and 118, shown in Fig. 6, to rotate mask 120 to correct for any rotation error during the exposure.

It is understood that by moving mask 120 in both the K and Y coordinates during exposure of plate 107, a change in the magnification factor may be achieved simultaneously with a change in the orthogonality factor and correction of any rotation error.

Fig. 6 shows a side view of mask fine stage 104, in accordance with one embodiment of the present invention. Mask fine stage 104 includes a mask frame 110 that is attached to coarse stage 102. A mask holder 112 is connected to mask frame 110 via actuators 114, 116, and 118. Mask 120 is held by mask holder 112 in a conventional manner, as is well understood by those skilled in the art. Actuators 114, 116, and 118 are disposed between mask holder 112 and mask frame 110 such that they can move mask holder 112 in the K, Y, and e- coordinates as shown by arrow 105, while coarse

stage 102 moves at a constant velocity in the K
coordinate as shown by the arrow 103. It is understood
that reference to the motion of mask 120 includes the
motion of mask holder 112 while mask frame 110 remains
5 stationary relative to coarse stage 102.

As shown in Fig. 6, actuator 114 moves mask holder
112 along the K coordinate, while actuators 116 and 118
move mask holder 112 in the Y coordinate when they are
simultaneously moved in the same direction. Actuators
10 116 and 118 also move mask holder in the O~ direction
if one actuator is moved in one direction more than the
other actuator, however, the O~ coordinate is
unnecessary to change the orthogonality or
magnification of the exposed image.

15 To control the accuracy of the system, the actual
position of mask 120 must be measured relative to a
known fixed position and relative to plate 107. The
actual position of mask holder 112 can be measured by a
conventional position measurement system, such as an
20 interferometer. Fig. 6 shows reflectors (mirrors) 122,
124, and 126 mounted on mask holder 112, which are used
by an interferometer (not shown) / via incident light
beams to measure the position of mask holder 112 in the
K, Y, and z coordinates. Because interferometers are
25 differential devices, the position of mask holder 112
is measured relative to another component of the

microlithographic system, such as projection lens 109,
to obtain the actual position of mask holder 112. The
position of mask holder 112 is also measured relative
to plate stage 106. Thus, plate stage 106 also has
5 reflectors mounted on it (not shown) to measure its
position in the K, Y, and z coordinates. With the
information regarding the position of mask holder 112,
the position of mask 120 may be calculated. Measuring
the current location of a stage with interferometers
10 is well known to those skilled in the art.

In an alternative embodiment, mask holder 112 is
connected to coarse stage 102 via actuators 114, 116,
118, obviating the need for mask frame 110. In such an
embodiment, actuators 116 and 118 are disposed between
15 mask holder 112 and coarse stage 102 and are used to
move mask holder 112 in the Y and z coordinate
directions. Actuator 114 may be directly attached to
coarse stage 102 and used to directly move mask holder
112 along the K coordinate. Thus, in this embodiment,
20 the entire mask fine stage 104 moves relative to plate
107.

Fig. 7 shows a close up side view of an example of
actuator 114, including an attached encoder 115. It is
understood that actuators 116 and 118 are the same as
25 actuator 114. Actuator 114, which is e.g. a voice- coil
actuator, includes a voice coil or other suitable motor

130 attached to mask frame 110. Motor 130 moves a shaft 132, which drives a wedge 134 in a direction parallel to mask frame 110, as shown by arrow 135. The movement of wedge 134 is translated to a roller 136, which moves
5 perpendicularly to mask frame 110 due to wedge 134, as shown by arrow 137. Roller 136 is in contact with mask holder 112, and thus the perpendicular motion of roller 136 is thereby translated to mask holder 112. It is understood that actuator 114 is shown by way of example,
10 and other actuators may be alternatively used, including, for example, other types of electro-magnetic actuators and screw type actuators.

An encoder 115 is directly attached to shaft 132 of actuator 114 to determine the amount of drive
15 provided to mask holder 112 through actuator 114. Encoder 115 measures the position of actuator 114. Position control apparatus 108 uses the position information from encoder 115 to measure the rate of change of position of actuator 114, which is
20 approximately a measure of the velocity of mask holder 112 relative to coarse stage 102. Because encoder 115 is directly attached to actuator 114, any flexation or vibration of mask holder 112 will have little affect on the measurement of the velocity of mask holder 112.
25 Additional encoders are likewise directly attached to respective actuators 116 and 118.

Actuators 114, 116, 118, shown in Fig. 6, are controlled by position control apparatus 108, shown in Fig. 3. Position control apparatus 108 receives position of fine stages 104, 106 through the use of
5 interferometers and the encoders attached to actuators 114, 116, and 118. Using this information, position control apparatus 108 control the motion of mask 120 through actuators 114, 116, 118 such that mask 120 has a velocity proportional to plate 107 that is
10 proportional to the desired magnification or orthogonality factor. For example, where no magnification or orthogonality factor is desired, position control apparatus 108 moves mask 120 such that mask 120 and plate 107 remain aligned in the K and Y
15 coordinates. Thus, any magnification or orthogonality error is corrected. However, where, for instance, a magnification factor of 1.1 is desired, position control apparatus 108 updates the K coordinate position of mask 120 relative to plate 107 by an amount equal to
20 ten percent of each change in the K coordinate position of coarse stage 102. consequently, mask 120 moves relative to plate 107 at ten percent of the velocity of coarse stage 102.

While correcting the magnification or
25 orthogonality of the exposed image, position control apparatus 108 may simultaneously dynamically correct

the synchronous error between mask fine stage 104 and plate fine stage 106, such as that caused by yaw and roll of coarse stage 102. In addition, position control apparatus 108 may reduce the settling time for coarse stage 102 to accelerate to the constant velocity.

Control of the synchronous error and reduction of settling time are described in the above- referenced copending application entitled "POSITION CONTROL APPARATUS FOR FINE STAGES CARRIED BY A COARSE STAGE ON A HIGH-PRECISION SCANNING POSITIONING SYSTEM, " by Bausan Yuan, and Kazuaki Saiki, co-pending application serial number 09/045,218.

Figs.8A, 8B, and 8C are graphic representations of the respective acceleration, velocity and position in the K coordinate of coarse stage 102 in relation to time during a scan, while Fig. 8C represents the velocity of fine stage 104 in the K coordinate in relation to time. During scanning, coarse stage 102 is moved by position control apparatus 108, shown in Fig. 3, such that coarse stage 102 is stationary at time t_0 and is moving at a constant velocity V_c at time t_1 , as shown in Figs 8A and 8B. Exposure of plate 107 on plate fine stage 106 does not occur until coarse stage 102 has reached an exposure point $X_{\sim}$ at time t_{ex} , as shown in Fig. 8C, by which time coarse stage 102 is at the desired constant velocity V_c , as shown in Fig. 8B.

Coarse stage 102 continues to move at constant velocity V_c until time t_2 , when exposure of plate 107 ends and coarse stage 102 begins to decelerate. Thus, the exposure of plate 107 occurs between times t_{ex} and t_2 .

5 Fig. 8C shows the velocity of mask fine stage 104 in the K coordinate with respect to time. As can be seen in Fig. 8C, mask fine stage 104 begins moving at time t_0 and by time t_1 mask fine stage 104, which carries mask 120, has reached a constant velocity v_f .

10 Mask 120 must reach a desired position relative to plate 107 at time t_{ex} to achieve the desired synchronization between mask 120 and plate 107. Thus, beginning the motion of mask 120, such as at time t_1 , when mask 120 and plate 107 are aligned will result in
15 a following error with mask 120 and plate 107 not properly synchronized. To avoid a following error, mask 120 is prepositioned relative to plate 107 before the scan begins.

20 Fig. 9 shows a top view of mask 120 and plate 107 carried on coarse stage 102 in relation to the beginning exposure point. Mask fine stage 104 and plate fine stage 106 are not shown in Fig. 9 for clarity of explanation. For simplicity sake, the beginning exposure point is illustrated as being at the point
25 when mask 120 and plate 107 are aligned. Prior to the beginning of the scan as illustrated in Figs 8A-8D,

mask 120 is prepositioned in the negative K direction by a distance X according to the following:

$$X = X_{ex} (b-1) \quad \text{equ. 1}$$

5

where X_{ex} is the distance traveled by coarse stage between time t_0 and t_{ex} /and b is the magnification factor. The prepositioned mask 120 is indicated in Fig. 9 with the broken lines.

10

When coarse stage 102 begins to move in the K coordinate direction, indicated by arrow 103, at time t_0 , mask 120 will begin to move in the direction, as indicated by arrow 105, to synchronize with plate 107. Mask 120 will travel a distance X by time t_{ex} and, thus, mask 120 and plate 107 will be properly aligned at time t_{ex} , at which time exposure of plate 107 occurs.

15

Position control apparatus 108 provides to actuators 114, 116, and 118 an update to the desired position of mask 120 during each update cycle of position control apparatus 108, shown in Fig. 3, based on the desired position of coarse stage 102 and the magnification factor according to the following:

20

$$X_m = X(b-1) \quad \text{equ. 2}$$

25

where X_m is the desired position value of mask 120, K is the desired position value of coarse stage 102, and

b is the magnification factor. It is appreciated that where position control apparatus 108 controls the movement of mask 120 by controlling the velocity of mask 120, the magnification factor is multiplied by the
5 desired velocity of coarse stage 102.

Additionally, feedforward signals are generated by position control apparatus 108 and provided to actuators 114, 116, and 118 to compensate for following error and to reduce settling time. The feedforward
10 signals are generated by multiplying the command trajectory velocity V and the magnification factor $(b-1)$. Consequently, when the exposure of plate 107 begins at time t_{ex} mask 120 and plate 107 will be in proper alignment and mask 120 will already be moving at a rate
15 that is proportional to the desired magnification factor. It is understood that where a decrease of magnification is desired, mask 120 is prepositioned an amount $-X$ in the scanning direction prior to beginning the scan because mask 120 moves in the opposite of the
20 scanning direction during exposure.

Similarly, when a change in orthogonality of the exposed image is desired, mask 120 may be prepositioned in the negative direction that mask 120 will be traveling during the exposure of plate 107. The amount
25 of the preposition is based on the desired orthogonality factor such that:

$$Y = X_{ex}(p-1) \text{ equ.3}$$

where X_{ex} is the distance traveled by coarse stage
between time t_0 and t_{ex} , and p is the orthogonality
5 factor.

In the above embodiment, the explanation is
described referring so-called a vertical type exposure
apparatus in which the plate 107 and the mask 120 are
arranged along a vertical direction and are moved to
10 transfer an erected image of a pattern of the mask onto
the substrate. The stage control method and an exposure
method or the like as stated in the above embodiment
can be applied to an exposure apparatus in which a
wafer and a reticle are arranged along a horizontal
15 direction, the wafer and the reticle are respectively
moved in opposed directions to each other and an
inverted image of a pattern of the reticle is projected
on the substrate. Such apparatus will be explained
referring Fig. 10.

20 In an scanning type exposure apparatus as shown in
Fig. 10, an illumination light for exposure from an
excimer laser source (KrF, ArF), not shown, enters into
an illumination optical system 150 through a light
guide optical system, not shown. The illumination
25 optical system has a blind mechanism, fly-eye lens, and
condenser lens etc. and illuminates a reticle R with an

illumination light formed in a predetermined area. A reticle scanning stage 180 and a reticle fine stage 180a drive the reticle R in a scanning direction (X-direction). The reticle fine stage 180a is connected to
5 the reticle scanning stage 180 and is driven in X-direction with following a wafer stage WST stated below. The reticle fine stage 180a is controlled according the control explained in the above embodiment. Further, the reticle fine stage 180a can perform fine- rotation for
10 yawing correction. Moving mirrors 136 and 136a for reflecting a distance measuring beam from laser interferometers 135, 135a are fixed at portions of the reticle scanning stage 180 and the reticle fine stage 180a so that the position of the reticle R in X-
15 direction is real-timely measured by the laser interferometers 135, 135a.

A pattern image formed on the reticle R is reduced , for example one-quarter, and is imaged on the wafer W by the projection optical system PL. The wafer W is
20 mounted on the wafer stage WST which is movable in X, Y and Z directions and is driven on the basis of an instruction from the wafer driving system 137.

During exposure operation, the reticle R is scanned at a constant speed V1 in the X-direction which is
25 perpendicular to a longitudinal direction of the illumination area thereof by driving the reticle

scanning stage 180 and the reticle fine stage 180a by means of the reticle driving system 134. In synchronization with the scanning, the wafer W is scanned at a constant speed V_2 in $-x$ direction with respect to a reticle image in the illumination area by driving the wafer stage WST by means of the wafer driving system 137. Assuming that the magnification from the reticle R to the wafer W in the projection optical system is $\hat{a}$, the speed V_2 should be set to be $\hat{a} \times V_1$. In such way, by synchronizing scanning of the reticle R and the wafer W, all patterns of the reticle is projected on the wafer W. When the exposure for one exposure area has been completed, a scanning start position of next exposure area on the wafer W moves into an exposure field of the projection optical system PL by driving the wafer stage WST by means of a stage driving unit.

Further, a moving mirror 139 for reflecting a distance measuring beam from the laser interferometer 138 is fixed at one end in X direction of the wafer stage WST and the position of the wafer stage WST in the X direction is real-time measured by means of the laser interferometer 138. Further a moving mirror for reflecting a distance measuring beam from the laser interferometer is fixed at one end of the wafer stage WST in the Y direction also similarly to the X

direction and the position of the wafer stage WST in the Y direction is real-timely measured by the interferometer.

5 Additionally, the control of the exposure operation in the scanning type exposure apparatus is totally controlled by a main controller 141. The basic operations of the the main controller 141 is to perform the relative movement of the wafer stage WST and the reticle fine stage 180a based on the position
10 information obtained from the laser interferometers 135, 135a and 138 and the speed information etc from the driving systems 134, 137 etc, with keeping a predetermined ratio(depending on the magnification of the projection optical system PL) of the speed of the
15 reticel fine stage 180a with respect to the speed of the wafer stage WST during the scanning exposure and suppression of the relative positional relationship between the reticle patter and the wafer pattern within a predetermined alignment error. Beside, instead of the
20 reticle fine stage 180a, a wafer stage fine stage may be provided to be connected to the wafer stage WST.

 While the above embodiments are directed to exposure apparatuses using KrF, Arf, or F2 laser (wavelength :157 nm), the light to be used in the
25 exposure apparatus according to the present invention is not limited to be them and the present invention may

be applied to EUV exposure apparatus using a light
having the wavelength of 5-15 nm as the exposure
illumination light, X-ray exposure apparatus, an ion
beam exposure apparatus using a charged particle beam
also.

While the present invention has been described in
connection with specific embodiments, variations of
these embodiments will be obvious to those of ordinary
skill in the art. For example, mask holder 112 may be
connected directly to coarse stage 102, thus obviating
the need for mask frame 110. Further, fine stages 104,
106 can be modified such that change in magnification
and orthogonality is achieved by moving plate fine
stage 106 while holding mask fine stage 104 stationary.
Therefore, the spirit and scope of the appended claims
should not be limited to the foregoing description.

INDUSTRIAL APPLICABILITY

In the method and apparatus according to the present
invention, a desired magnification and orthogonality
can be realized, for example, when this invention is
applied to a micro-lithograph apparatus, an apparatus
in which a pattern on a reticle can be transferred on a
wafer with a desired status, can be realized.

This Sheet Has Been Replaced

**CLAIMS**

1. A method comprising:
- starting a scan of a first stage along a first coordinate, wherein said first stage carries a second stage and a third stage;
- measuring a position of said second stage in said first coordinate and in a second coordinate relative to said third stage; and
- moving said second stage along said first coordinate relative to said third stage at a first velocity proportional to a desired magnification factor.
2. The method of Claim 1, further comprising:
- moving said second stage along said second coordinate relative to said third stage at a second velocity proportional to a desired orthogonality factor.
3. The method of Claim 1, further comprising:
- exposing a plate carried by said third stage by illuminating a mask carried by said second stage with radiant energy when said first stage is at an approximately constant velocity in its scan.
4. The method of Claim 1, wherein said second stage holds a mask and said third stage holds a plate.
5. The method of Claim 3, further comprising:
- repositionin said second stage in the negative of the direction said second stage moves in said first





coordinate prior to said step of starting said scan,
wherein said prepositioning is by an amount ΔX where:

$$X = X_{ex}(b-1)$$

5

where X_{ex} is the distance said coarse stage moves
between the step of starting to scan and the step of
exposing said plate, and b is the magnification factor.

6. The method of Claim 3, further comprising:

10 prepositioning said second stage in the negative of
the direction said second stage moves in said second
coordinate prior to said step of starting said scan,
wherein said prepositioning is by an amount ΔY where:

$$15 \quad Y = X_{ex}(p-1)$$

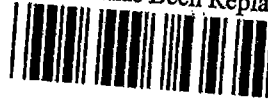
where X_{ex} is the distance said first stage moves between
the step of starting to scan and the step of exposing
said plate, and p is the orthogonality factor.

7. The method of Claim 1, further comprising

20 compensating for synchronous error between said second
stage and said third stage after the step of starting
said scan.

8. The method of Claim 1, further comprising
multiplying a feedforward signal by said magnification
25 factor, said feedforward signal being received by said
second stage to compensate for a following error of





said first stage.

9. A method comprising:

starting a scan of a first stage along a first
coordinate, wherein said first stage carries a second
stage and a third stage;

measuring a position of said second stage in said
first coordinate and in a second coordinate relative to
said third stage; and

moving said second stage along said second coordinate
relative to said third stage at a velocity proportional
to a desired orthogonality factor.

10. A scanning apparatus, comprising:

a first stage moving along a first coordinate;

a second stage movably mounted to said first stage;

a third stage mounted to said first stage;
a mechanism for moving said second stage along said
first coordinate relative to said third stage at a
first velocity proportional to a magnification factor;
and

a position control circuit, said position control
circuit controls said mechanism for moving said second
stage along said first coordinate.

11. The scanning apparatus of Claim 10, wherein said
second stage comprises a fine stage frame

fixedly attached to said first stage, and a holder
movably coupled to said fine stage frame, wherein said





holder moves along said first coordinate relative to said fine stage frame.

12. The scanning apparatus of Claim 11, wherein said mechanism for moving said fine stage

5 along said first coordinate comprises a first actuator disposed between said fine stage frame and said holder.

13. The scanning apparatus of Claim 10, further comprising:

10 mechanism for moving said second stage along a second coordinate relative to said second fine stage at a second velocity proportional to an orthogonality factor; and wherein said position control circuit controls said means for moving said second stage along said second coordinate.

15 14. The scanning apparatus of Claim 13, wherein said second stage is comprised of a fine stage frame fixedly attached to said first stage, a holder movably coupled to said fine stage frame, wherein said holder moves along said first coordinate and said second coordinate relative to said fine stage frame.

20 15. The scanning apparatus of Claim 13, wherein said mechanism for moving said fine stage along said second coordinate comprises a second actuator disposed between said fine stage frame and
25 said holder.



16. An exposure apparatus for projecting a pattern
of a mask on a substrate, said apparatus comprising:
a first stage which moves said mask;
a second stage which moves said substrate;
5 a third stage connected to either one of said
first and second stages; and
a driver which drives said third stage prior to
the start of said projection.

17. An exposure apparatus according to claim 16,
10 wherein said third stage is driven at the substantially
same time of the movement of said first stage.

18. An exposure apparatus according to claim 16,
wherein said third stage is positioned at a position
which is offset from an exposure starting position of
15 either one of said first and second stages.

19. An exposure apparatus according to claim 16,
wherein said third stage is connected to said first
stage and holds said mask.

20. An exposure apparatus according to claim 16,
20 wherein said apparatus comprises a scanning type
exposure apparatus in which said patten is projected on
said substrate during a synchronous movement of said
mask and said substrate.

This Sheet Has Been Replaced

