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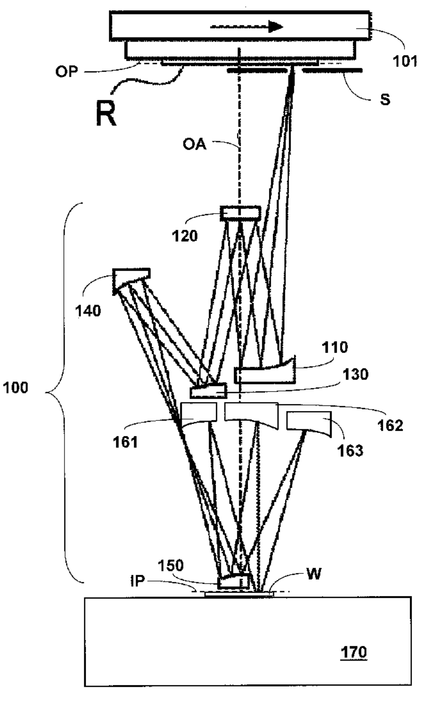
(54) Title: PROJECTION OBJECTIVE OF A MICROLITHOGRAPHIC EXPOSURE APPARATUS

Fig. 1



(57) Abstract: The invention concerns a projection objective of a microlithographic projection exposure apparatus designed for EUV, for imaging an object plane illuminated in operation of the projection exposure apparatus into an image plane, wherein the projection objective has at least one mirror segment arrangement (160, 260, 280, 310, 410, 500) comprising a plurality of separate mirror segments (161 -163; 261-266, 281 -284; 31 1, 312; 41 1, 412; 510-540); and wherein associated with the mirror segments of the same mirror segment arrangement are partial beam paths which are different from each other and which respectively provide for imaging of the object plane (OP) into the image plane (IP), wherein said partial beam paths are superposed in the image plane (IP) and wherein at least two partial beams which are superposed in the same point in the image plane (IP) were reflected by different mirror segments of the same mirror segment arrangement.

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PROJECTION OBJECTIVE OF A MICROLITHOGRAPHIC EXPOSURE APPARATUS

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority of German Patent Application DE 10 2010 043 498.1 and US 61/410,521, both filed on November 5, 2010. The content of these applications is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

Field of the invention

The invention concerns a projection objective of a microlithographic projection exposure apparatus designed for EUV and a method of optically adjusting a projection objective.

State of the art

Microlithography is used for the production of microstructured components such as for example integrated circuits or LCDs. The microlithography process is carried out in a so-called projection exposure apparatus having an illumination system and a projection objective. In that case the image of a mask (= reticle) illuminated by means of the illumination system is projected by means of the projection objective onto a substrate (for example a silicon wafer) which is coated with a light-sensitive layer (photoresist) and arranged in the image plane of the projection objective to transfer the mask structure onto the light-sensitive coating on the substrate.

Mirrors are used as optical components for the imaging process in projection objectives designed for the EUV range, that is to say at wavelengths of for example about 13 nm or about 7 nm, due to the lack of availability of suitable translucent refractive materials.

Typical projection objectives designed for EUV as are known for example from US 7 538 856 B2 can for example have an image-side numerical aperture (NA) in the range from 0.2 to 0.3 and reproduce an object field (for example which is annular) in the image plane or wafer plane.

In the case of approaches for increasing the image-side numerical aperture (NA), a problem which arises in practice is that limits are set in many respects on an increase in the size of the mirror surfaces, that is linked to that increase in the numerical aperture; on the one hand, with increasing dimensions of the mirrors, it becomes increasingly difficult to reduce in particular long-wave surface errors to values below the required limit values, in which respect the larger mirror surfaces require inter alia greater aspheres. In addition increasing dimensions for the mirrors require larger processing machines for manufacture, and stricter requirements are placed on the machining tools used (such as for example grinding, lapping and polishing machines, interferometers and cleaning and coating installations). In addition, the manufacture of larger mirrors makes it necessary to use heavier mirror base bodies which, as from a certain limit, can scarcely still be mounted in position or flex beyond an acceptable degree due to the force of gravity.

A further problem involved with the increase in mirror dimensions results from shadowing of regions of the illumination beam path. In that respect it is admittedly possible to use systems with central obscuration but therein the above-described problems still arise.

It is known inter alia from WO 2008/020965 A2 to produce a collector mirror of the EUV light source by a plurality of discrete substrate being directed towards a common focal point and then each coated with a multiple layer which is reflective for EUV. To orient the collector mirror which for example is in the form of an ellipsoidal mirror one or more actuators are used for orientation of at least one of the substrate relative to a carrier structure, such orientation process being effected in dependence on a measurement of the light which is deflected from a first focal point to a second focal point of the ellipsoidal mirror.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a projection objective of a microlithographic projection exposure apparatus which permits implementation of higher numerical apertures while at least substantially avoiding the above-described production-engineering problems.

That object is attained by the features of independent claim 1.

A projection objective according to the invention of a microlithographic projection exposure apparatus designed for EUV, for imaging an object plane illuminated in operation of the projection exposure apparatus into an image plane, has at least one mirror segment arrangement comprising a plurality of separate mirror segments, wherein associated with the mirror segments of the same mirror segment arrangement are partial beam paths which are different from each other and which respectively provide for imaging of the object plane into the image plane, wherein said partial beam paths are superposed in the image plane and wherein at least two partial beams which are superposed in the same point in the image plane were reflected by different mirror segments of the same mirror segment arrangement.

In that respect adjacent mirror segments in the mirror segment arrangement according to the invention can be optically seamlessly assembled together or can also be at a finite spacing relative to each other, which can be governed either by the production process or which can also be specifically targetedly provided for the purposes of adjustment of the mirror segment arrangement.

The partial beam paths which according to the invention are superposed in the image plane and which respectively involve imaging of the object plane (or the mask) into the image plane or wafer plane and the images of which are superposed in the image plane are also referred to here and hereinafter as “simultaneous partial beam paths”.

The invention is based in particular on the concept of embodying at least one mirror in the imaging beam path of a projection objective in segment-wise manner, that is to say replacing a monolithic mirror by a mirror segment arrangement comprising a plurality of separate mirror segments.

Furthermore, at least two partial beams which are superposed in the same point in the image plane were reflected by different mirror segments of the same mirror segment arrangement. Accordingly, according to the invention, one and the same point in the image plane is reached by beams which have been reflected by different mirror segments of the mirror segment arrangement and which superpose in said point in the image plane. With other words, one object field is projected into one image field with contribution or collaboration of different mirror segments of the same mirror segment arrangement. The invention therefore e.g. differs from prior art concepts of optical systems having different optical groups in such a sense that different object fields (which are spatially separated from each other) are attributed via separate optical paths (including different mirrors as beam guiding components) to different image fields, with one and the same point in the object field being exclusively irradiated by beams which have been reflected by one single mirror. In contrast to such concepts, the present invention makes it possible to realize significant higher numerical apertures.

That segment-wise structure of at least one mirror, that is to say the replacement thereof by a mirror segment arrangement with separate mirror segments, has substantial advantages in terms of production engineering insofar as on the one hand the maximum diameter to be processed in respect of the mirror segment arrangement according to the invention can be substantially less (only for example of the order of magnitude of 70% or less) than the maximum diameter of a corresponding unsegmented mirror. Under some circumstances consequently manufacture is only now made technologically possible at all, or it is possible to avoid additional capital investment in new and larger production machines. On the other hand, as the individual mirror segments can be thinner, the components to be handled are of a substantially lower (overall) mass, just by way of example of the order of magnitude of 25% or less, in comparison with a corresponding unsegmented mirror. As a consequence of the reduction in the total mass, gravity-induced deformation of the mirror segments or arrangement due to the inherent weight thereof can also be reduced.

The disclosure also relates to a projection objective according to the invention of a microlithographic projection exposure apparatus designed for EUV, for imaging an object plane illuminated in operation of the projection exposure apparatus into an image plane has at least one mirror segment arrangement comprising a plurality of separate mirror segments, wherein associated with the mirror segments of the same mirror segment arrangement are partial beam paths which are different from each other and which respectively provide for imaging of the object plane into the image plane, wherein said partial beam paths are superposed in the image plane.

In an embodiment the at least one mirror segment arrangement is the reflecting arrangement of the projection objective, which arrangement is last in relation to the beam path at the image plane side.

In an embodiment the at least one mirror segment arrangement is the reflecting arrangement of the projection objective having the maximum size of the total optically effective surface (i.e. the total reflecting surface).

In an embodiment the at least one mirror segment arrangement has at least three mirror segments, in particular at least four mirror segments.

In an embodiment the mirror segments of the same mirror segment arrangement respectively form with each other a continuous reflecting surface interrupted only by transitional regions which are optionally present between adjacent mirror segments.

In an embodiment there are provided at least two mirror segment arrangements which each have at least two separate mirror segments, wherein associated with the mirror segments of the same mirror segment arrangement are beam paths which are different from each other and which respectively provide for imaging of the object plane into the image plane and which are superposed in the image plane.

In an embodiment a respective one of the mirror segments of the one mirror segment arrangement is associated with one of the mirror segments of the other mirror segment arrangement in pair-wise relationship with the same partial beam path.

In an embodiment there is further provided a shutter arrangement so designed that illumination of the at least one mirror segment arrangement can be selectively limited to different mirror segments of said mirror segment arrangement.

The invention also relates to a projection objective of a microlithographic projection exposure apparatus designed for EUV, for imaging an object plane illuminated in operation of the projection exposure apparatus into an image plane, wherein the projection objective comprises a plurality of mirrors, and wherein the mirror of said plurality of mirrors having the maximum size is formed as a mirror segment arrangement comprising a plurality of separate mirror segments.

As further discussed below, the segmented configuration of the largest mirror (which can be in particular the last mirror at the image plane side) is particularly advantageous since said mirror is particularly relevant for the numerical aperture (NA) at the image side.

In a further aspect of the invention account is taken of the fact that intermediate spaces occur between the individual mirror segments and influence the imaging properties. That problem can occur in particular in connection with the last mirror in the beam path, if more specifically that mirror is not exactly in a pupil plane by virtue of a beam path which is telecentric at the image plane side, and consequently the induced imaging errors have a field-dependent component.

The invention now involves the concept that arranging a suitable obscuration shutter arrangement in the pupil plane of the system makes it possible to provide an obscuration effect which is precisely or at least partially such that the aforementioned mirror segment intermediate spaces lie in the shadow of the obscuration shutter or the shadow of that obscuration out of the pupil plane precisely or at least partially covers the mirror segment intermediate spaces. In other words according to the invention use is made of the fact that the mirror segment intermediate spaces remain without having a disturbing influence on the imaging properties insofar as just the shadow of the obscuration shutter arrangement is produced on the corresponding region. With other words, the shadow projection of the obscuration shutter on the mirror segment arrangement at least partially covers over the mirror segment intermediate spaces. Accordingly, light which – without the obscuration shutter - would be incident on mirror segment intermediate spaces is blinded out/stopped down by the obscuration shutter.

With the foregoing background in mind in accordance with an embodiment there is provided an obscuration shutter in a pupil plane of the projection objective, wherein the obscuration shutter is so designed that the shadow projection of the obscuration shutter on the mirror segment arrangement covers over the mirror segment intermediate spaces.

In an advantageous embodiment in addition the at least one mirror segment arrangement is designed in such a way (or with such a “partition” between the individual mirror segments) that mirror segment intermediate spaces between the mirror segments are of a geometry which is at least region-wise of an annular shape or in the shape of a ring segment. Such an annular geometry for the mirror segment intermediate spaces has the additional advantage that no orientation-dependent imaging effects occur, due to obscuration. In contrast (in relation to the light propagation direction or the optical system axis) mirror segment intermediate spaces which are arranged at different azimuth angles and which extend in the radial direction have the effect that certain diffraction orders pass into the region of the mirror segment intermediate spaces and other diffraction orders do not go onto the mirror segment intermediate spaces so that structures involving a mutually different orientation exhibit a different imaging characteristic. The above-described concept however is not limited to mirror segment intermediate spaces which are in ring form or in the shape of a ring segment, so that other geometries are also embraced, in which the mirror segment intermediate spaces lie in the shadow of the obscuration shutter.

As the obscuration shutter arrangement is to have an influence on the imaging properties, that is as slight as possible or causes little disturbance, it preferably involves a rotational symmetry (without however the invention being restricted thereto). The influence of the obscuration shutter arrangement on the imaging properties is at its slightest when the obscuration shutter arrangement is of an annular geometry as then each structure to be imaged or each diffraction order experiences the same obscuration effect, independently of its orientation. In further embodiments the obscuration shutter arrangement can also be designed with an n-fold symmetry (in particular a four-fold symmetry) with respect to the optical system axis so that the same obscuration is achieved for certain structures or diffraction orders.

In a further aspect the invention also concerns a method of producing a projection objective of a microlithographic projection exposure apparatus designed for EUV, for imaging an object plane illuminated in operation of the projection exposure apparatus into an image plane, said projection objective having a plurality of mirrors, wherein at least one of said mirrors is composed of a plurality of separate mirror segments.

According to an embodiment, the composing of said mirror of a plurality of separate mirror segments is made such that at least two partial beams which are superposed in the same point in the image plane were reflected by different mirror segments of said plurality of separate mirror segments.

According to an embodiment, said mirror composed of a plurality of separate mirror segments is the last in relation to the beam path at the image plane side.

According to an embodiment, said mirror composed of a plurality of separate mirror segments is the mirror having the maximum size of the total optically effective surface.

According to an embodiment, at least two of those mirror segments can be optically seamlessly joined together (for example by wringing). In addition at least two of those mirror segments can also be fixed at a finite spacing relative to each other.

In a further aspect the invention also concerns a method of optically adjusting a projection objective of a microlithographic projection exposure apparatus, wherein the projection objective has a plurality of mirrors which are oriented during the adjustment operation into their working position for the lithography process, wherein the projection objective has at least one mirror segment arrangement comprising a plurality of separate mirror segments and wherein adjustment is effected in at least two adjustment steps which differ from each other in respect of the mirror segments contributing to imaging of the object plane into the image plane in the respective adjustment step.

The invention further concerns an arrangement for optically adjusting a projection objective of a microlithographic projection exposure apparatus, wherein the projection objective has a plurality of mirrors which are oriented during the adjustment operation into their working position for the lithography process, wherein the projection objective has at least one mirror segment arrangement comprising a plurality of separate mirror segments, wherein the arrangement has at least one variable shutter arrangement by means of which illumination of the mirror segment arrangement can be selectively limited to one or more of the mirror segments.

Further configurations of the invention are to be found in the description and the appendant claims.

The invention is described in greater detail hereinafter by means of embodiments by way of example illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

Figure 1 shows a diagrammatic view to illustrate the structure of a projection objective according to an embodiment of the invention,

Figure 2 shows a diagrammatic view to illustrate the structure of a projection objective according to a further embodiment of the invention,

Figure 3 shows different views to illustrate different possible shutter arrangements in a measuring arrangement according to the invention,

Figure 4 shows a diagrammatic view of a possible structure according to the invention to illustrate the structure of a measuring arrangement for simultaneous partial beam paths,

Figure 5 shows a diagrammatic view to illustrate a further embodiment of the invention, and

Figures 6 - 11 show diagrammatic views to illustrate a further aspect of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Figure 1 shows a diagrammatic view of the structure of a projection objective 100 in which a mirror is replaced by a mirror segment arrangement comprising separate mirror segments. The basic structure of the projection objective (without the segmentation according to the invention) is known from US 7 538 856 B2 and as such does not belong to the claimed subject-matter of the present application.

In the projection objective 100 EUV radiation is incident from an illumination system (not shown) on a mask (reticle) R having structures to be imaged through a slot S which defines the region of the mask R, that is to be illuminated. The projection objective 100 has a plurality of mirrors (in the illustrated embodiment, six mirrors) 110-160, wherein the mirror 160 which is last in relation to the beam path at the image plane side, as is only diagrammatically shown in Figure 1, is in the form of mirror segment arrangement comprising separate mirror segments 161, 162 and 163.

The segmented configuration of the mirror which is last at the image plane side (and at the same time the largest) is particularly advantageous insofar as that mirror is particularly relevant for the numerical aperture (NA) at the image side.

The invention however is not limited thereto so that, instead of the mirror which is last at the image plane side, another mirror of the projection objective 100 can also be subdivided into separate segments. In further embodiments a plurality of mirrors (that is to say two or more mirrors) can also be subdivided into separate segments, as is described hereinafter with reference to Figure 2. It will be appreciated that in addition the number selected in Figure 1 of three mirror segments is only by way of example and it is also possible to provide segmentation into more or fewer mirror segments (that is to say only two).

The projection objective 100 is telecentric at the image plane side but non-telecentric at the object plane side (that is to say on the part of the mask R) in order to avoid interference phenomena with the light incident from the illumination system.

A measuring arrangement 170 which is only diagrammatically indicated here serves, as is described in greater detail hereinafter, for measurement of the simultaneous partial beam paths or the superpositioning thereof.

Figure 2 shows a diagrammatic view illustrating the structure of a projection objective 200 according to a further embodiment of the invention, in which there are two mirrors of segmented nature. The basic structure of the projection objective (without the segmentation according to the invention) is known from WO 2009/052932 A1 and as such does not belong to the claimed subject-matter of the present application.

The projection objective 200 has six unsegmented mirrors 210-250 and 270 and two mirror segment arrangements 260, 280 of which the mirror segment arrangement 280 which is last in relation to the beam path is subdivided into four mirror segments 281-284 while the mirror segment arrangement 260 which is in the third-from-last position in the direction of light propagation is subdivided into six mirror segments 261-266.

In addition the mirror segment arrangements 260 and 280 and mirrors 270 which are disposed in the last three positions in relation to the beam path on the image plane side are respectively obscured and have a through opening for light incident on the position of the optical axis OA. The mirror 250 which is disposed in the fourth-from-last position in relation to the beam path is not obscured and produces a shadowing defined by its outer peripheral edge in a pupil plane PP of the projection objective. There is an intermediate image IMI between the mirror segment arrangement 280 which is last in relation to the beam path, and the image plane IP.

In the projection objective 200 in Figure 2, a respective one of the mirror segments 261-266 of the mirror segment arrangement 260, with one of the mirror segments 281-284 of the other mirror segment arrangement 280, is associated in pair-wise relationship with the same partial beam path. Both such a pair of mirror segments (namely that comprising the mirror segments 261 and 284) and also the corresponding portion a partial beam path are emphasized by arrows in Figure 2. The totality of all of those pairs of segments defines a set of simultaneous partial beam paths. A measuring arrangement which is diagrammatically indicated in Figure 2 and denoted by reference 290 and described hereinafter serves to ensure that on the one hand each partial beam path is stigmatic in itself and on the other hand the images respectively produced by the partial beam paths overlap in the wafer plane in accordance with the respective image structure width.

To adjust the projection objective the mirror segments of the mirror segment arrangement are oriented both relative to each other and also (as a whole) relative to the system by way of actuators. Accordingly the invention also concerns a combination with a measuring arrangement and an actuator system which permits adjustment of the mirror segments. The measuring arrangement according to the invention can be both already used during assembly or initial adjustment of the system and also during ongoing operation or in the scanner of the projection exposure apparatus.

A basically suitable arrangement is described in WO 2007/062808 A1 which discloses a “grazing incidence interferometer” for measurement of an active mirror. That interferometer can be used in a similar fashion for measurement of the mirror segment arrangement according to the invention. Furthermore, a system wave front interferometer as is disclosed in US 2008/0144043 A1 can also be used to check the orientation of the overall mirror. When using that interferometer, use is made of the fact that the aberrations of the projection objective are influenced by a variation in mirror position or orientation, wherein those changes in aberration in turn can be detected by means of the system wave front interferometer.

Simultaneous partial beam paths (in accordance with the foregoing definition) are already there when there is only one mirror segment arrangement present, the superpositioning of which partial beam paths should now be so precise that the images which are respectively produced by the partial beam paths in the image plane and which are in mutually superposed relationship are identical in terms of the resolution achieved by the projection objective and coincide as exactly as possible. Accordingly there are two challenges for the measuring arrangement: on the one hand it is to ensure that the optical distortion effects in respect of all simultaneous beam paths are identical within certain tolerance limits, and on the other hand the respective images should be superposed as exactly as possible within the resolution limits.

A basic possible embodiment of a measuring arrangement for the simultaneous partial beam paths and their superpositioning is described hereinafter with reference to Figures 3a – c and Figure 4.

An optical projection system 300 and 400 respectively which is only indicated in Figures 3a – c and Figure 4, similarly to the above-described embodiments, includes at least one mirror segment arrangement 310 and 410 respectively, wherein for the sake of simplicity only one further (unsegmented) mirror 320 and 420 respectively is shown.

The measuring arrangement of Figure 4 has at least one detector 455 arranged downstream of the projection objective 400 (only diagrammatically indicated), in the light propagation direction. In addition the measuring arrangement has a measuring light source 401 upstream of the projection objective 400 in the light propagation direction, the measuring light source 401 producing radiation with defined properties in the object plane.

The measuring arrangement for the simultaneous partial beam paths and the superpositioning thereof is to perform in particular the following tasks:

a) measuring the aberrations of the wave front produced by a partial beam path when imaging a point light source (sometimes also referred to as the “system wave front”). The point light source can be arranged at various locations in the object plane OP, preferably in the region of the so-called scanner slot. Suitable arrangements and methods for measuring those aberrations are known for example from US 2008/0144043 A1 or US 7 333 216 B2.

b) measuring the distortion of the image produced by a partial beam path, in particular in the region of the scanner slot. Suitable arrangements and methods for distortion measurement are also known in the state of the art, for example from US 7 019 824 B2.

c) measuring the superpositioning of the images produced by at least two partial beam paths in the image plane IP or wafer plane, in particular in the region of the scanner slot S.

In addition the measuring arrangement has a selectively acting shutter arrangement 415 for selecting given solid angle regions of the light, which makes it possible to limit the illumination of at least one mirror segment arrangement selectively to different ones of the mirror segments.

In relation to the light propagation direction as diagrammatically shown in Figures 3a–c, such a shutter arrangement can be arranged either directly downstream of the mask R (see reference 315 in Figure 3a) disposed in the object plane OP, between two mirrors or mirror segment arrangements 310 and

320 (see reference 316 in Figure 3b) or in the light propagation direction directly upstream of the detector arrangement (see reference 317 in Figure 3c).

In that respect, for selection of the partial beam paths by means of the shutter arrangement, it is advantageous to dispose all individual openings in a common shutter plane and to select a respective one thereof by a displaceable shutter. The openings in the shutter arrangement are determined in terms of position and size by the partial beam path produced by the measuring light source 301 and 401 respectively, along the respective pairs of mirrors. Thus for each partial beam path there exists an associated shutter opening of respective position, shape and size.

The measurement arrangement according to the invention makes it possible in particular to be able to check the respective contribution of the individual partial beam paths to the (overall) image produced in the image plane, separately or in targetedly selectable combinations.

To perform the above-described tasks in accordance with a) and b), the methods already referred to are known from the state of the art. By combination with the above-described shutter arrangement for selection of the partial beam paths, it is thus possible to measure aberration and distortion for each partial beam path.

Performance of the task in accordance with c), that is to say for measuring the superpositioning of the images produced by at least two partial beam paths in the wafer plane, involves the selectively acting shutter arrangement according to the invention being combined with further measuring arrangements for superpositioning of the images.

The measuring arrangement for superpositioning of the images produced by the partial beam paths must evaluate at least one surface element in positionally resolved fashion in the image plane in order to be able to provide information about the superpositioning. For that purpose the apparatus based on the moiré principle for distortion measurement in accordance with above-mentioned US 7 019 824 B2 can be suitably enlarged, as diagrammatically shown in Figure 4:

Referring to Figure 4 a first pattern 402 arranged in the object plane OP is imaged onto a second pattern 435 arranged in the image plane IP and by superpositioning forms a moiré pattern which in turn can be imaged by a subsequent optical imaging system 445 and recorded by a positional resolving camera 455. Similarly to the above-described embodiments the optical projection system 400 only indicated in Figure 4 includes at least one mirror segment arrangement 410, only one further (unsegmented) mirror 420 being shown for the sake of simplicity. The first pattern 402 and the second pattern 435 can be embodied in particular in “parquet-like” fashion in order to obtain information in different spatial directions, with the minimum possible number of measurement steps. Evaluation of the moiré pattern formed by superpositioning makes it possible to recognize differences between the optically produced image and the second pattern, in particular distortions which correspond to changes in image position. For building up the image in a stepwise procedure optical imaging can be effected systematically by way of one or more partial beam paths, in which respect different partial beam path effects can be compared together and their cooperation can be checked.

A possible method of orienting and adjusting the partial beam paths with respect to each other using that measuring arrangement can take place as follows:

Firstly a first partial beam path is selected by means of the shutter arrangement 415 and the superpositioning of the image of the first mask 402 arranged in the object plane OP with the second mask 403 arranged in the image plane is observed for that first partial beam path, with the masks 402, 403 being oriented relative to each other. The distortion in the first partial beam path can be inferred from the first moiré pattern which is produced in that case. Then, with the mask positions being unaltered, a second partial beam path is selected by means of the shutter arrangement 415 and produces a second moiré pattern, wherein deviations in that second partial beam path from the first partial beam path lead to differences between the second moiré pattern and the first moiré pattern. Deviations in the optical properties of the second partial beam path from the first partial beam path can be inferred from the deviations between the two moiré patterns. In addition, with that knowledge, the second partial beam path can be optimized in relation to the first partial beam path in respect of image position and distortion by way of a suitable manipulator system. That step is repeated for all partial beam paths so that as a result all partial beam paths are oriented relative to each other.

In accordance with a further embodiment the position of the shutter arrangement 415 can also be altered in such a way that more than one partial beam path simultaneously contributes to imaging. In that case the individual partial images are superposed incoherently in the image plane to form a multiple partial image which can also be evaluated as described. That combination can be implemented at the same time until opening of all partial beam paths occurs so that as a result the overall projection objective is adjusted with all mirror segment arrangements.

Figure 5 shows a diagrammatic view to illustrate a further embodiment of the invention. For that purpose Figure 5 shows a segmentation by way of example of a (comparatively large) rotationally symmetrical mirror which is near the pupil and which has a mirror opening or mirror bore for a beam to pass therethrough. The exit pupil is centrally obscured. A mirror segment arrangement 500 is afforded by the segmentation of that mirror in an initially similar fashion to the above-described embodiments.

In this case segmentation in the mirror segment arrangement 500 is effected in dependence on the respectively set illumination setting. In other words, before selecting a suitable segmentation, the illumination setting used is firstly established. The transitional regions or “cuts” between the individual mirror segments are so selected in that case that no diffraction order is incident on those transitional regions.

In the specific example in Figure 5 the illumination setting has four illumination poles 501-504 which are respectively turned through 45° relative to the y-axis, the respective diffraction orders being illustrated for horizontally and vertically oriented dense lines respectively.

In conjunction with that illumination setting, as shown in Figure 5 segmentation or division of the mirror segment arrangement 500 into four mirror segments 510-540 is adopted, which are respectively arranged in the corresponding four segments turned through 45° with respect to the y-axis in the illustrated coordinate system.

The arrangement in Figure 5 makes it possible on the one hand to compensate for field-constant low-order pupil errors, for example astigmatism and coma. A further advantage with this arrangement that it is only ever necessary to adjust relative to each other those ones of the mirror segments 510-540, which contribute to the diffraction image of the same structure. In the specific embodiment of horizontal and vertical dense lines, only two respective pairs of mirror segments are to be adjusted relative to each other, more specifically on the one hand the mirror segments 520 and 540 relative to each other and on the other hand the mirror segments 510 and 530 relative to each other. In contrast the relative arrangement for example of the mirror segment 520 relative to the mirror segment 530 or the mirror segment 510 is immaterial. That considerably reduces the demands on adjustment as, in comparison with an adaptive mirror which is used over the full surface area, only half the number of parameters have to be jointly controlled.

In addition there is an advantage in principle regarding the design of the projection exposure apparatus in that the functionalities of providing an “optical surface” and affording mechanical stability can be distributed to different components (“mirror segment” and “carrier structure”).

Figure 6 shows an embodiment of a mirror segment arrangement 600 which is designed in such a way (or with such a “partition” between the individual mirror segments) that mirror segment intermediate spaces between the mirror segments are of a geometry which is at least region-wise in a ring shape or in the shape of a ring segment.

The mirror segment arrangement 600 diagrammatically illustrated in Figure 6 includes a central mirror segment 610 as the “main mirror”, the size of which can be suitably selected in terms of aspects relating to production engineering, and the main mirror 610 can therefore also be produced with comparatively no problems. In addition the mirror segment arrangement 600 in the illustrated embodiment (and without the invention being restricted thereto) includes four mirror segments 620, 630, 640 and 650 as “secondary mirrors” which are in the form of circular ring segments with substantially radially extending segment intermediate spaces so that they are arranged around the central mirror segment 610 forming the main mirror, at a certain radial spacing relative to the central mirror segment 610. That radial spacing can be used for example for holder elements, sensor means and/or actuator means.

In addition the mirror segments 620, 630, 640 and 650 are at the minimum possible spacing relative to each other (that is to say in the azimuthal direction with respect to the optical system axis extending in the z-direction in the illustrated coordinate system) so that no structural space worth mentioning is required in the azimuthal direction. Consequently the above-discussed effect linked to the presence of azimuthal mirror segment intermediate spaces, namely that identical structures in a different orientation have different imaging characteristics, is at least substantially avoided.

Figures 7a and b show diagrammatic views illustrating examples of a respective obscuration shutter arrangement 710 and 720, as is arranged according to the invention preferably in a pupil plane or in the proximity thereof (as defined hereinafter with reference to Figure 9). In that respect the obscuration shutter arrangement 710 of Figure 7a is defined for an optical system without central pupil obscuration and the obscuration shutter arrangement 720 of Figure 7b is designed for an optical system with central pupil obscuration.

The regions which are respectively shadowed by the obscuration shutter arrangement 710 and 720 are respectively identified by 710a, 720a and 720b. The obscuration shutter arrangement 710 and 720, as described hereinafter, is so designed in each case that the shadow it casts on the mirror segment arrangement 600 covers over the radially extending mirror segment intermediate spaces. The aim and purpose of the respective obscuration shutter arrangement 710 and 720 is thus to previously cut out light which, without the obscuration shutter arrangement 710 and 720, would be incident in the annular gap A between the main mirror 610 and the secondary mirrors 620-650, so that field-dependent effects or field-dependent changes in the imaging characteristics are avoided.

Figure 8 shows an embodiment of a projection objective 800 designed for EUV radiation, with a numerical aperture of NA = 0.6, which for imaging the structures of a reticle R onto the wafer W has a total of eight mirrors 810-880, wherein the mirror 880 which is last at the image plane side with respect to the beam path can be in the form of a mirror segment arrangement comprising separate mirror segments. The second mirror 820 in the beam path forms a mirror near the pupil. Reference is directed to Figure 9 for the definition of the criterion of “pupil nearness” and also field nearness.

Referring to Figure 9 the pupil or field nearness respectively can be quantitatively described by way of a parameter P(M) (as described for example in US 2008/0165415 A1), wherein the parameter P(M) is defined as:

$$P(M) = \frac{D(SA)}{D(SA) + D(CR)} \qquad (1),$$

wherein D(SA) denotes the subaperture diameter and D(CR) denotes the maximum principal ray spacing (from all field points or defined over all field points of the optically used field) on the optical surface M in the plane in question. Thus P(M) = 0 applies for a field mirror (with a subaperture diameter of zero) and P(M) = 1 for a pupil mirror (with a principal ray spacing of zero). The above-mentioned mirror 820, like the obscuration shutter arrangement, is preferably disposed in a plane of the projection objective, in which the parameter P(M) is at least 0.8, in particular at least 0.9.

An obscuration shutter arrangement 890 (not shown in Figure 8) is also disposed in the pupil nearness in accordance with the foregoing definition. The obscuration shutter arrangement 890 as shown in Figure 10a has a ring-shaped obscuration shutter 891 and a central obscuration shutter 892. Figure 10b shows the respective shadowed regions which result out of the action of the obscuration shutter arrangement 890 at the location of the last mirror 880 at the image plane side, wherein reference 891a denotes the shadow of the ring-shaped obscuration shutter 891 and reference 892a denotes the shadow of the central obscuration shutter 892.

Figure 11 diagrammatically shows further possible embodiments of obscuration shutter arrangements 910, 920, 930 and 940. What is common to those obscuration shutter arrangements 910-940 is that they each involve a four-fold symmetry.

Referring to Figures 11a and b obscuration shutters 911-914 and 921-924 respectively which are suitable for forming the obscuration shutter arrangements 910 and 920 are arranged in the peripheral direction or azimuthally (with respect to the optical system axis extending in the z-direction in the illustrated coordinate system), and more specifically (with respect to the respective central axis or axis of symmetry), at an angle of 45°, 135°, 225° and 315° respectively with respect to the y-axis. In that case the geometry of the obscuration shutters 911-914 is so selected that this affords a cross-shape geometry of the non-shadowed region whereas the geometry of the obscuration shutters 921-924 is so selected that this affords a star-shaped geometry of the non-shadowed region.

It is to be noted that the concept according to the invention whereby the mirror segment intermediate spaces lie in the shadow of the obscuration shutter can also be embodied by the embodiment shown in Figure 11. It is to be noted however that in this case the above-described advantageous configuration with mirror segment intermediate spaces which are in the shape of a ring or ring segments is not afforded so that only a limited selection of illumination settings is permitted with these embodiments.

Referring to Figures 11c and d, obscuration shutters 931-934 and 941-944 respectively which are suitable for giving the obscuration shutter arrangements 930 and 940 are arranged in the peripheral direction or azimuthally (with respect to the optical axis extending in the z-direction in the illustrated coordinate system), and more specifically (with respect to the respective central axis or axis of symmetry), at an angle of 0°, 90°, 180° and 270° respectively with respect to the y-axis. In this case the geometry of the obscuration shutters 931-934 in Figure 11c is so selected, similarly to Figure 11a, that this gives a cross-shaped geometry of the non-shadowed region whereas the geometry of the obscuration shutters 941-944 in Figure 11d, similarly to Figure 11b, is so selected that this involves a star-shaped geometry of the non-shadowed region.

Even if the invention has been described by reference to specific embodiments numerous variations and alternative embodiments will be apparent to the man skilled in the art, for example by combination and/or exchange of features of individual embodiments. Accordingly it will be appreciated by the man skilled in the art that such variations and alternative embodiments are also embraced by the present invention and the scope of the invention is limited only in the sense of the accompanying claims and equivalents thereof.

CLAIMS

1. A projection objective of a microlithographic projection exposure apparatus designed for EUV, for imaging an object plane illuminated in operation of the projection exposure apparatus into an image plane,
   - wherein the projection objective has at least one mirror segment arrangement (160, 260, 280, 310, 410, 500) comprising a plurality of separate mirror segments (161-163; 261-266, 281-284; 311, 312; 411, 412; 510-540); and
   - wherein associated with the mirror segments of the same mirror segment arrangement are partial beam paths which are different from each other and which respectively provide for imaging of the object plane (OP) into the image plane (IP), wherein said partial beam paths are superposed in the image plane (IP) and wherein at least two partial beams which are superposed in the same point in the image plane (IP) were reflected by different mirror segments of the same mirror segment arrangement.

2. A projection objective as set forth in claim 1, characterized in that the at least one mirror segment arrangement (160, 260, 280, 310, 410, 500) is the reflecting arrangement of the projection objective, which arrangement is last in relation to the beam path at the image plane side.

3. A projection objective as set forth in claim 1 or claim 2, characterized in that the at least one mirror segment arrangement (160, 260, 280, 310, 410, 500) is the reflecting arrangement of the projection objective having the maximum size of the total optically effective surface.

4. A projection objective as set forth in one of claims 1 through 3, characterized in that the at least one mirror segment arrangement (160, 260, 280, 310, 410, 500) has at least three mirror segments (161, 162,

163; 261-266, 281-284; 411, 412; 510-540), in particular at least four mirror segments (261-266, 281-284; 510-540).

5. A projection objective as set forth in one of the preceding claims, characterized in that the mirror segments (161-163; 261-266, 281-284; 311, 312; 411, 412; 510-540) of the same mirror segment arrangement (160, 260, 280, 410, 500) respectively form with each other a continuous reflecting surface interrupted only by transitional regions which are optionally present between adjacent mirror segments.

6. A projection objective as set forth in one of the preceding claims, characterized in that there are provided at least two mirror segment arrangements (260, 280) which each have at least two separate mirror segments (261-266, 281-284), wherein associated with the mirror segments (161-266, 281-284) of the same mirror segment arrangement (260, 280) are beam paths which are different from each other and which respectively provide for imaging of the object plane (OP) into the image plane (IP) and which are superposed in the image plane (IP).

7. A projection objective as set forth in claim 6, characterized in that a respective one of the mirror segments (261-266) of the one mirror segment arrangement (260) is associated with one of the mirror segments (281-284) of the other mirror segment arrangement (280) in pair-wise relationship with the same partial beam path.

8. A projection objective as set forth in one of the preceding claims, characterized in that there is further provided a shutter arrangement (315, 316, 317, 415) so designed that illumination of the at least one mirror segment arrangement (310, 410) can be selectively limited to different mirror segments (311, 312, 411, 412) of said mirror segment arrangement.

9. A projection objective as set forth in one of the preceding claims, characterized in that at least two mirror segments of the mirror segment arrangement are movable relative to each other.

10. A projection objective of a microlithographic projection exposure apparatus designed for EUV, for imaging an object plane illuminated in operation of the projection exposure apparatus into an image plane,
    - wherein the projection objective comprises a plurality of mirrors; and
    - wherein the mirror of said plurality of mirrors having the maximum size is formed as a mirror segment arrangement (160, 260, 280, 310, 410, 500) comprising a plurality of separate mirror segments (161-163; 261-266, 281-284; 311, 312; 411, 412; 510-540).

11. A projection objective as set forth in one of the preceding claims, characterized in that there is further provided an obscuration shutter arrangement, wherein at least one mirror segment intermediate space remaining between mirror segments of the mirror segment arrangement is at least partially arranged in the shadow of said obscuration shutter arrangement.

12. A projection objective of a microlithographic projection exposure apparatus designed for EUV, for imaging an object plane illuminated in operation of the projection exposure apparatus into an image plane, comprising
    - at least one mirror segment arrangement (160, 260, 280, 310, 410, 500, 600) comprising a plurality of separate mirror segments (161-163; 261-266, 281-284; 311, 312; 411, 412; 510-540; 610-650); and

- an obscuration shutter arrangement (710, 720, 910, 920, 930, 940) wherein at least one mirror segment intermediate space remaining between mirror segments of the mirror segment arrangement is at least partially arranged in the shadow of said obscuration shutter arrangement (710, 720, 910, 920, 930, 940).

13. A projection objective as set forth in claim 11 or claim 12, characterized in that the at least one mirror segment intermediate space remaining between mirror segments of the mirror segment arrangement is of a rotationally symmetrical, in particular annular geometry.

14. A projection objective as set forth in one of claims 11 through 13, characterized in that the obscuration shutter arrangement is of a rotationally symmetrical, in particular annular geometry.

15. A projection objective as set forth in one of claims 11 through 14, characterized in that the obscuration shutter arrangement (710, 720, 910, 920, 930, 940) is arranged in a plane of the projection objective, in which a parameter P(M) which is defined as:

$$P(M) = \frac{D(SA)}{D(SA) + D(CR)},$$

is at least 0.8, in particular at least 0.9, wherein D(SA) denotes the subaperture diameter and D(CR) denotes the maximum principal ray spacing defined over all field points of the optically used field on the optical surface M in the plane in question.

16. A projection objective as set forth in one of claims 11 through 15, characterized in that the obscuration shutter arrangement (710, 720, 910,

920, 930, 940) is of n-fold, in particular four-fold symmetry with respect to the optical system axis, wherein n is a natural number greater than zero.

17. A method of producing a projection objective of a microlithographic projection exposure apparatus designed for EUV, for imaging an object plane (OP) illuminated in operation of the projection exposure apparatus into an image plane (IP), wherein said projection objective has a plurality of mirrors and wherein at least one of said mirrors is composed of a plurality of separate mirror segments (161-163; 261-266, 281-284; 311, 312; 411, 412; 510-540).

18. A method as set forth in claim 17, characterized in that at least two partial beams which are superposed in the same point in the image plane (IP) were reflected by different mirror segments of said plurality of separate mirror segments (161-163; 261-266, 281-284; 311, 312; 411, 412; 510-540).

19. A method as set forth in claim 17 or 18, characterized in that said mirror composed of a plurality of separate mirror segments is the last in relation to the beam path at the image plane side.

20. A method as set forth in one of the claims 17 through 19, characterized in that said mirror composed of a plurality of separate mirror segments is the mirror having the maximum size of the total optically effective surface.

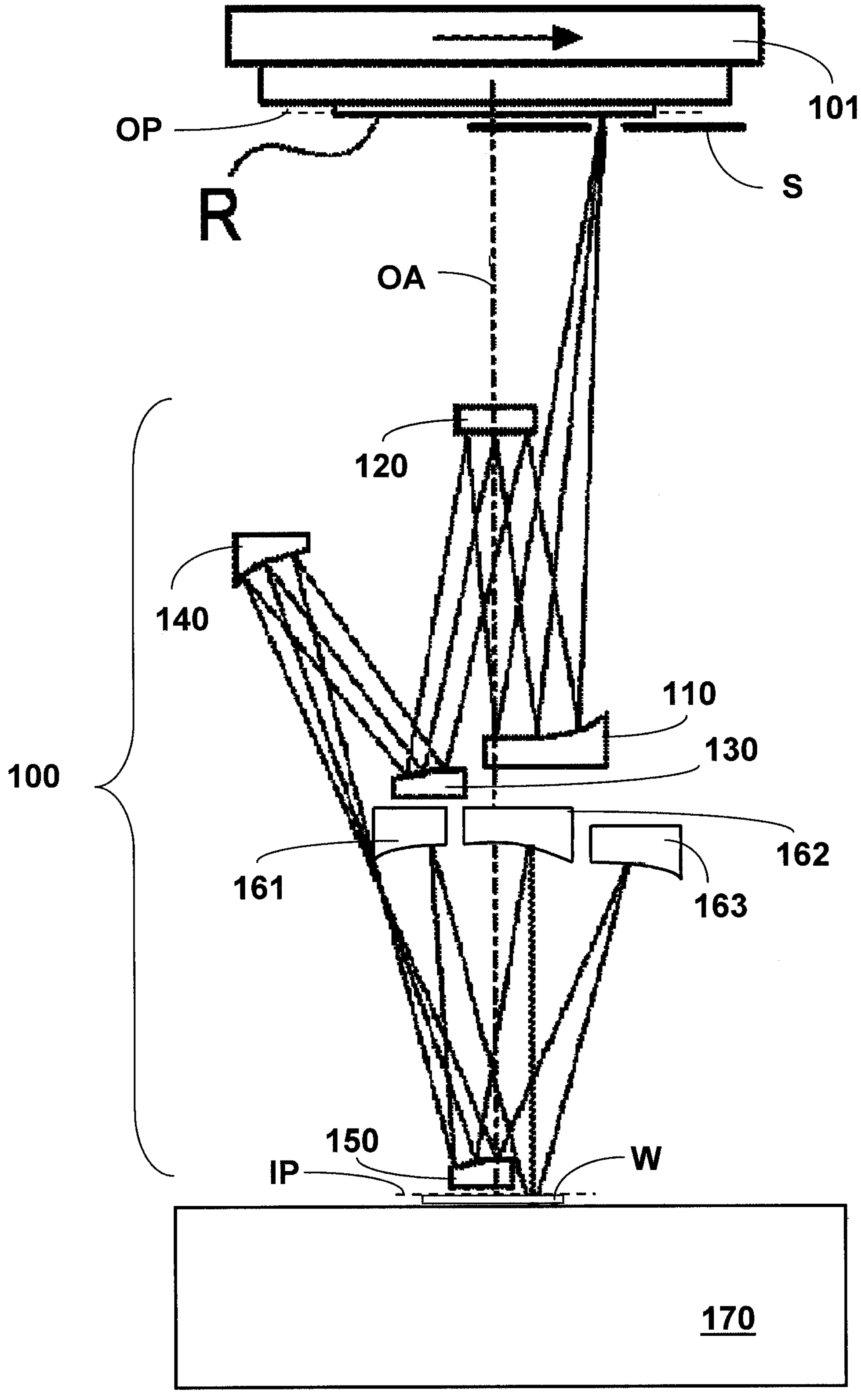
21. A method as set forth in one of the claims 17 through 20, characterized in that at least two of said mirror segments are optically seamlessly joined together.

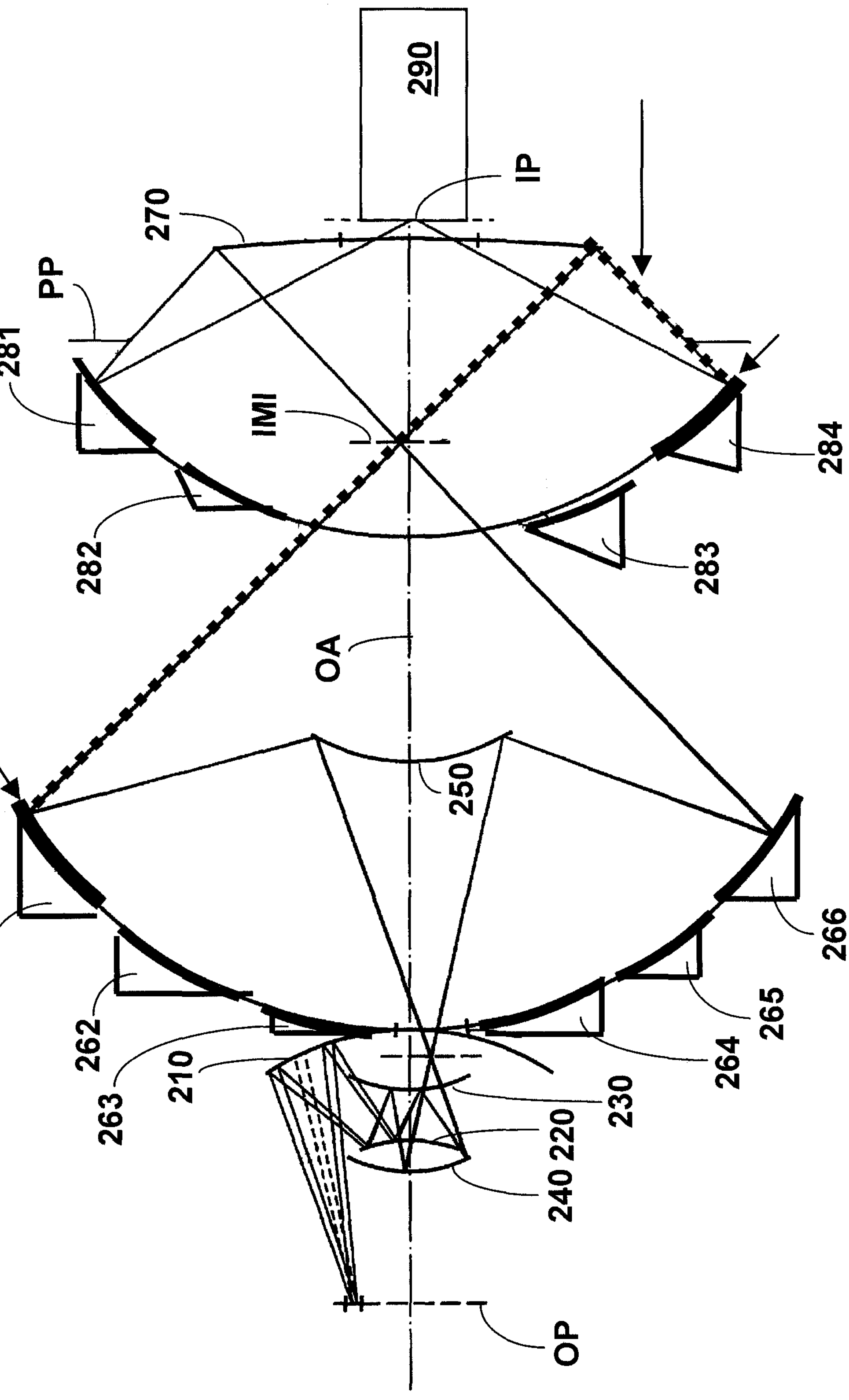
22. A method as set forth in one of the claims 17 through 21, characterized in that at least two of said mirror segments are fixed at a finite spacing relative to each other.

23. A method of optically adjusting a projection objective of a microlithographic projection exposure apparatus, wherein the projection objective has a plurality of mirrors which are oriented during the adjustment operation into their working position for the lithography process, wherein the projection objective has at least one mirror segment arrangement (160, 260, 280, 310, 410, 500) comprising a plurality of separate mirror segments (161, 162, 163; 261-266, 281-284; 311, 312; 411, 412; 510-540) and wherein adjustment is effected in at least two adjustment steps which differ from each other in respect of the mirror segments contributing to imaging of the object plane (OP) into the image plane (IP) in the respective adjustment step.

24. An arrangement for optically adjusting a projection objective of a microlithographic projection exposure apparatus, wherein the projection objective has a plurality of mirrors which are oriented during the adjustment operation into their working position for the lithography process, wherein the projection objective has at least one mirror segment arrangement (160, 260, 280, 310, 410, 500) comprising a plurality of separate mirror segments (161, 162, 163; 261-266, 281-284; 311, 312; 411, 412; 510-540), wherein the arrangement has at least one variable shutter arrangement (315, 316, 317, 415) by means of which illumination of the mirror segment arrangement (160, 260, 280, 310, 410, 500) can be selectively limited to one or more of the mirror segments (161, 162, 163; 261-266, 281-284; 311, 312; 411, 412; 510-540).

Fig. 1

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PP
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IMI
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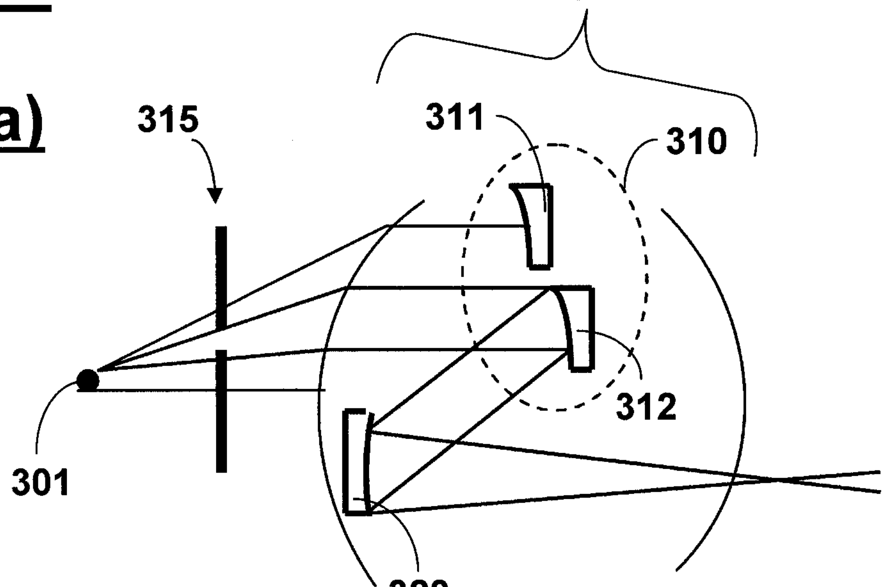
265
266
OP

Fig. 2

Fig. 3

a)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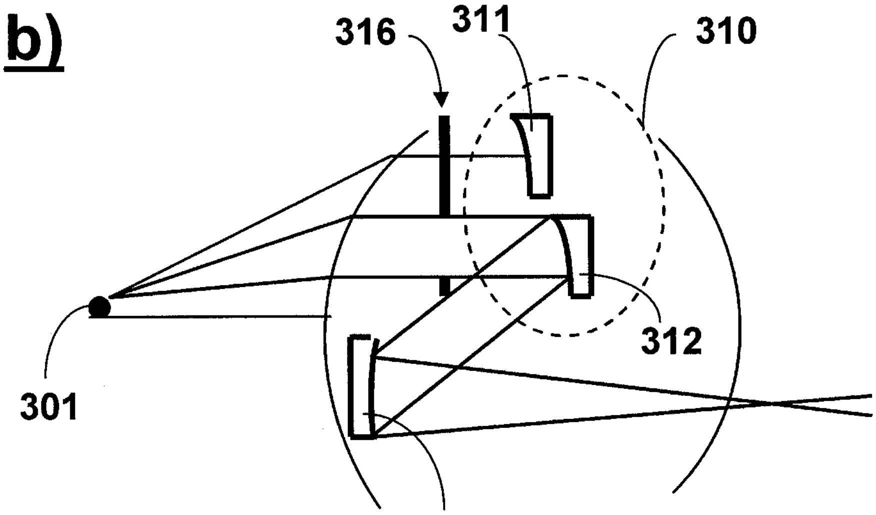
b)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310
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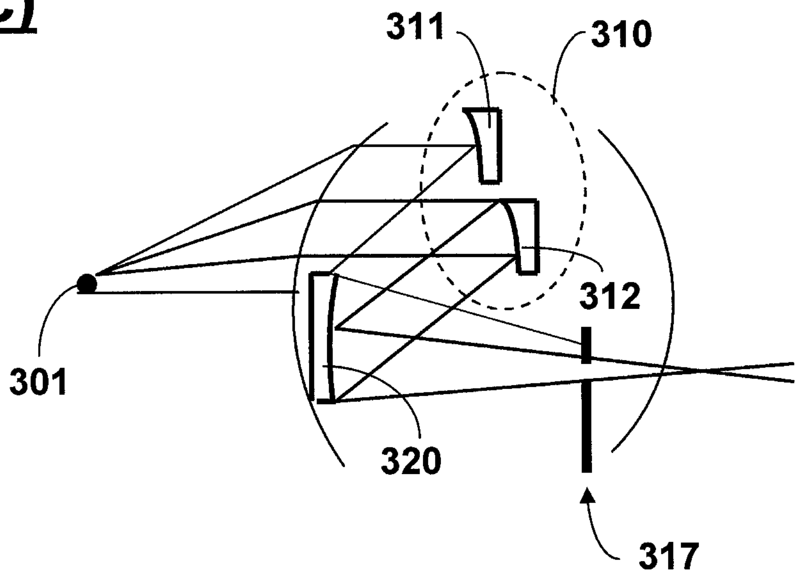
320

c)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312
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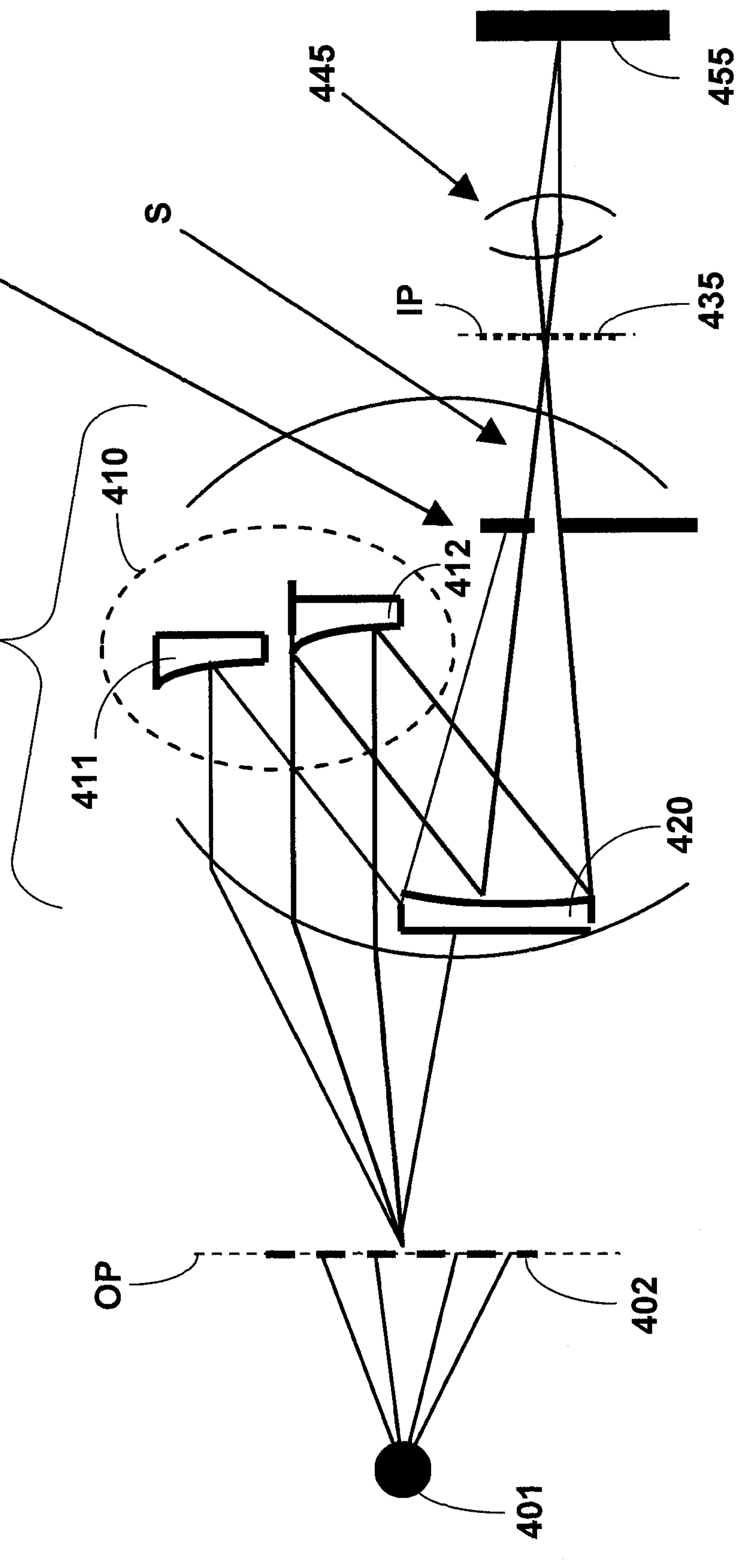


Fig. 4

Fig. 5

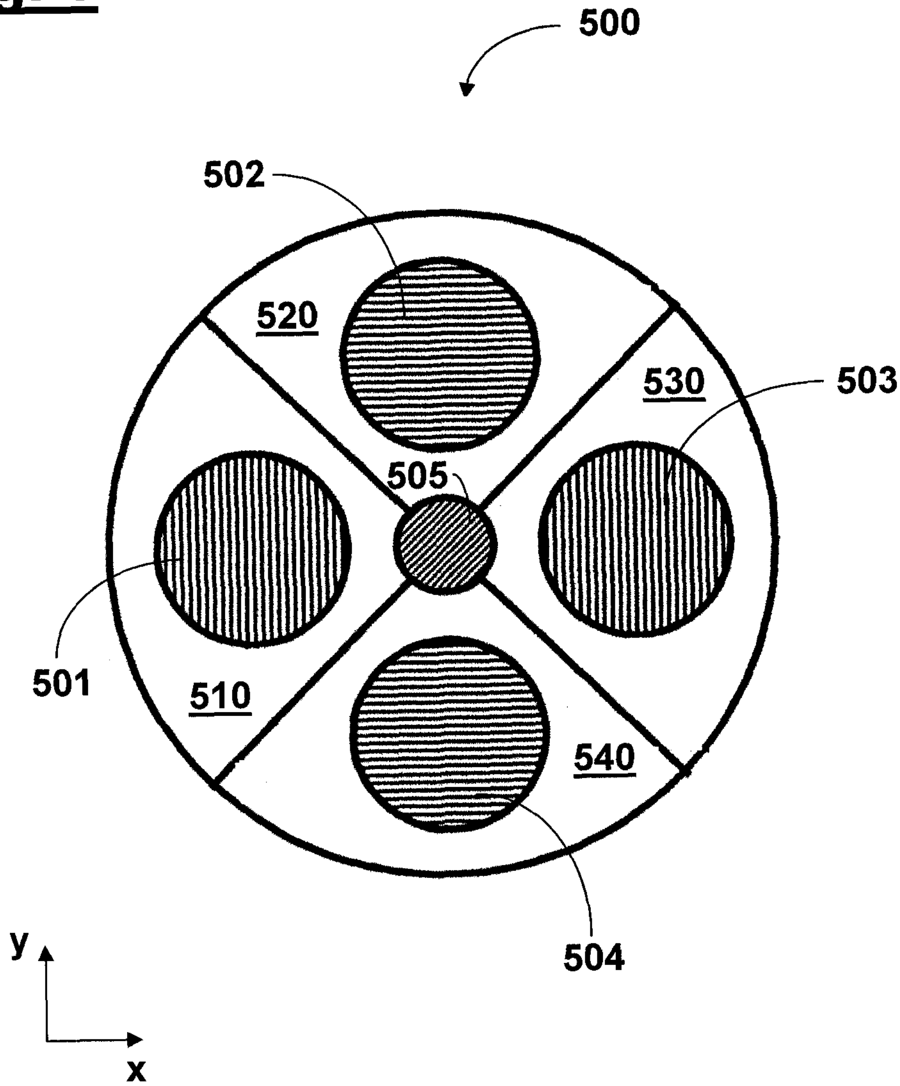


Fig. 6

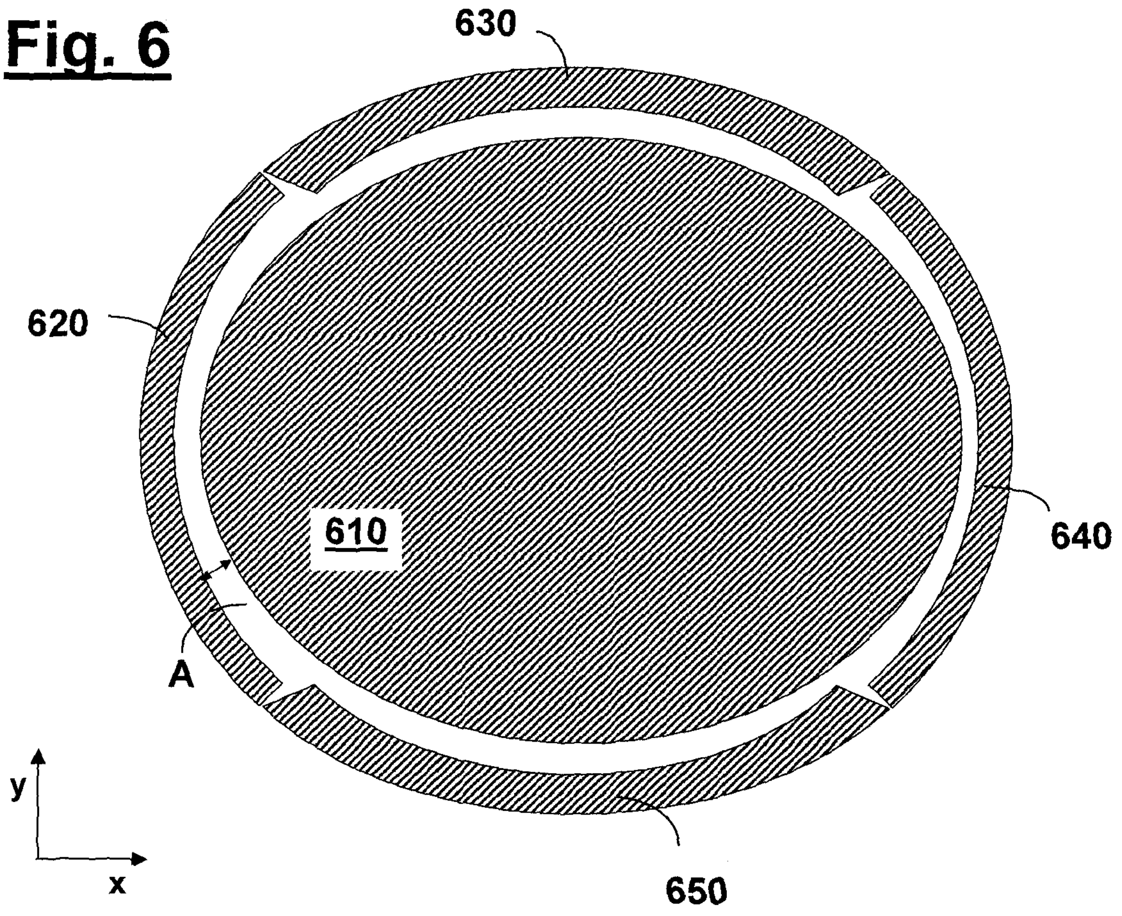


Fig. 7a

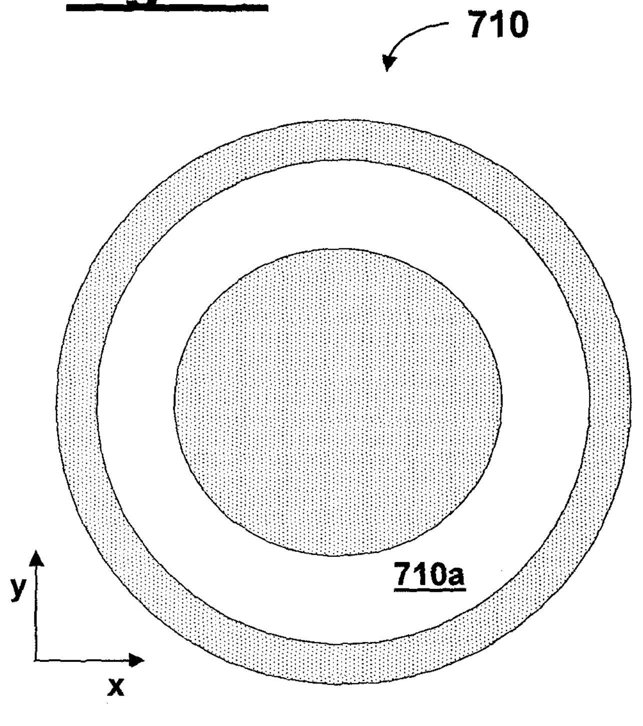
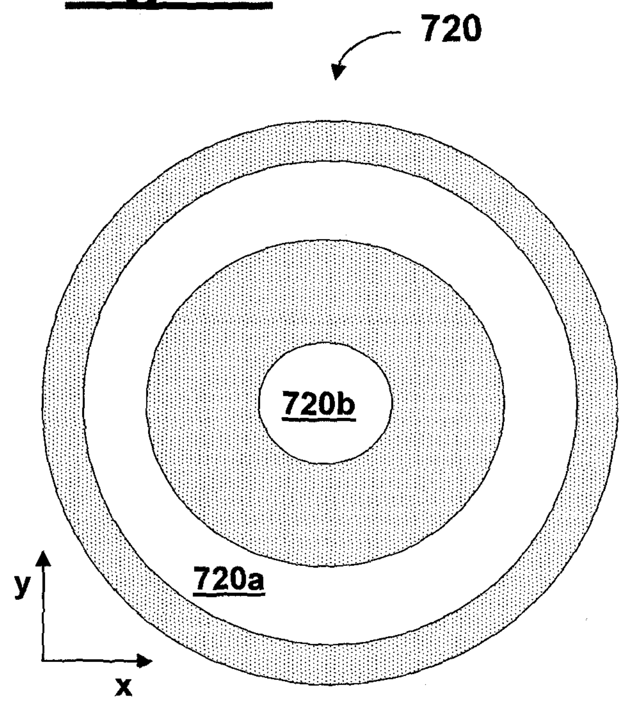


Fig. 7b



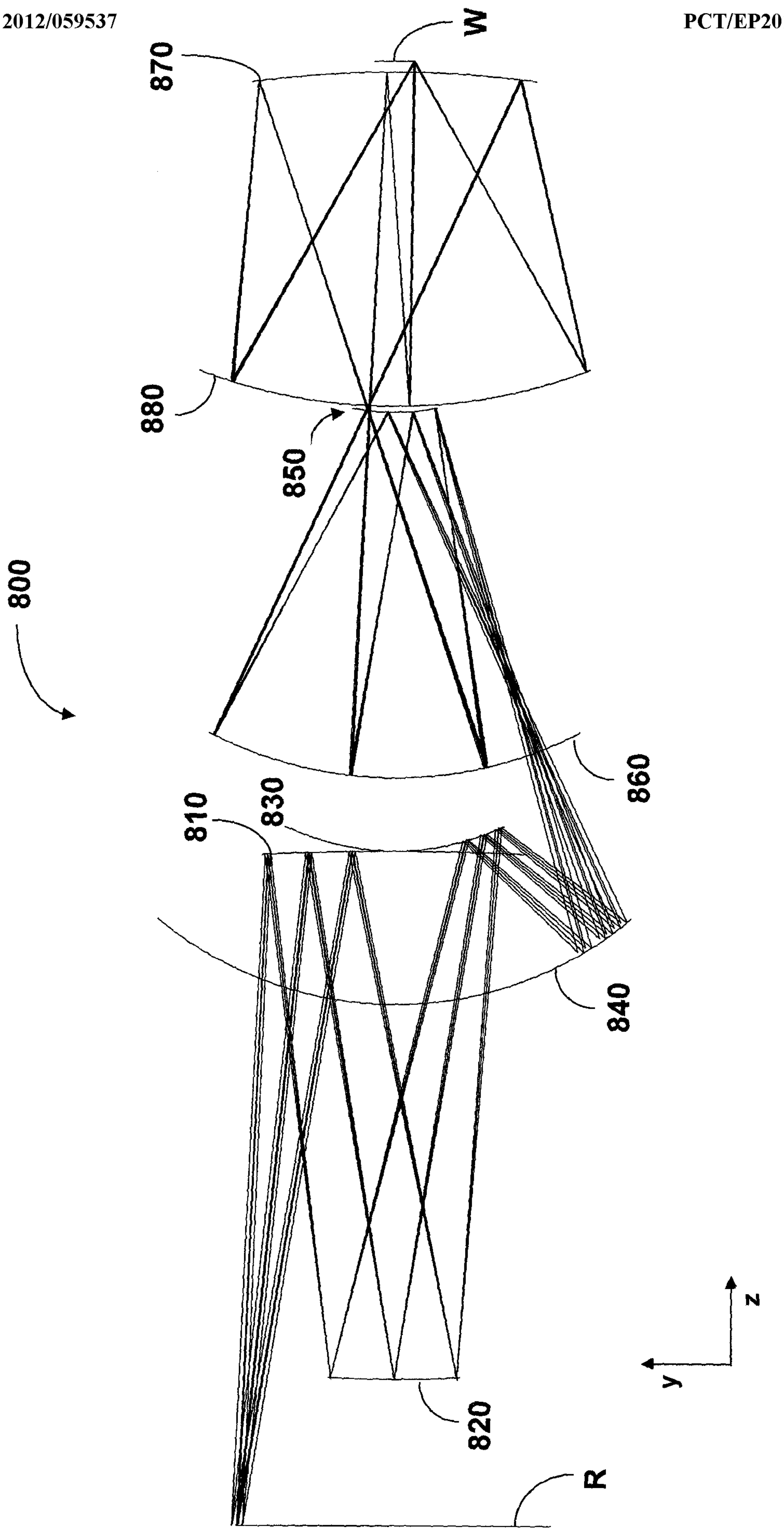


Fig. 8

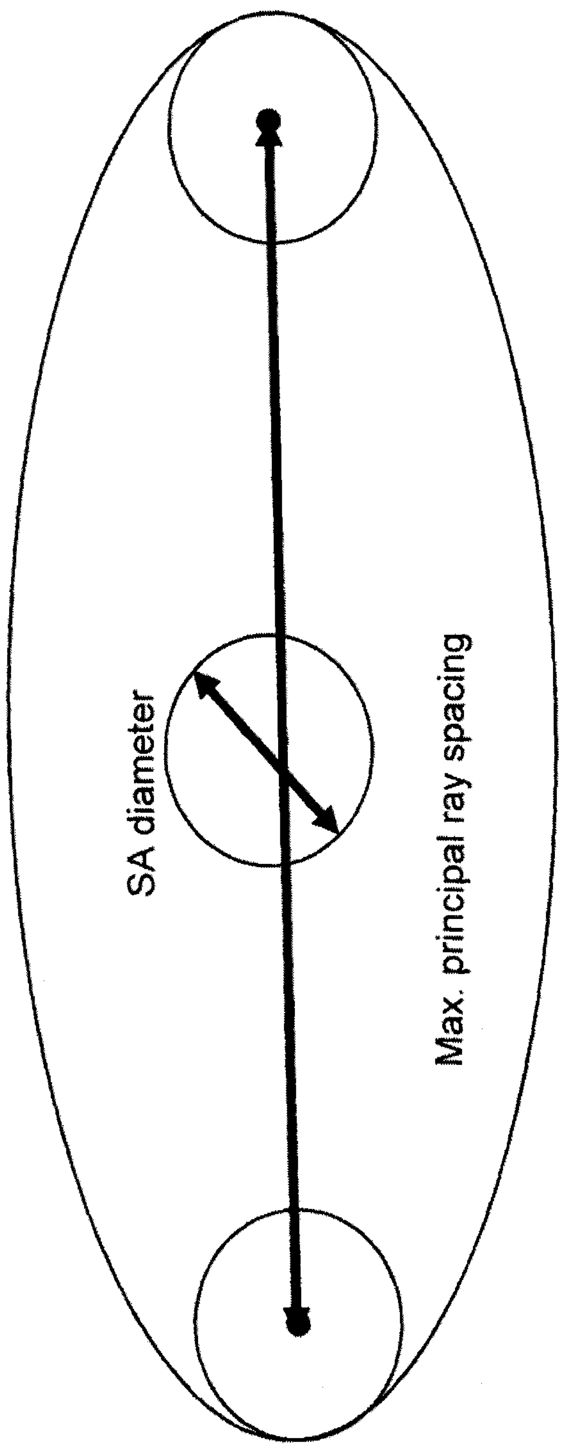


Fig. 9

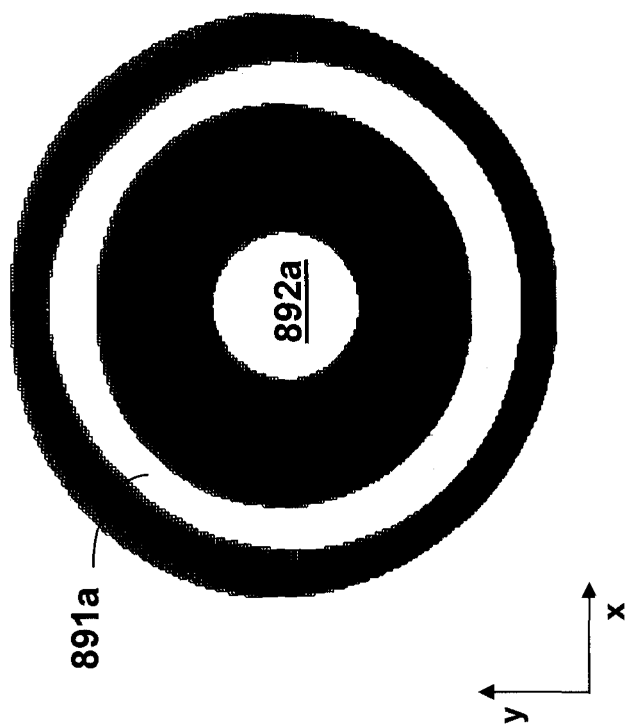


Fig. 10b

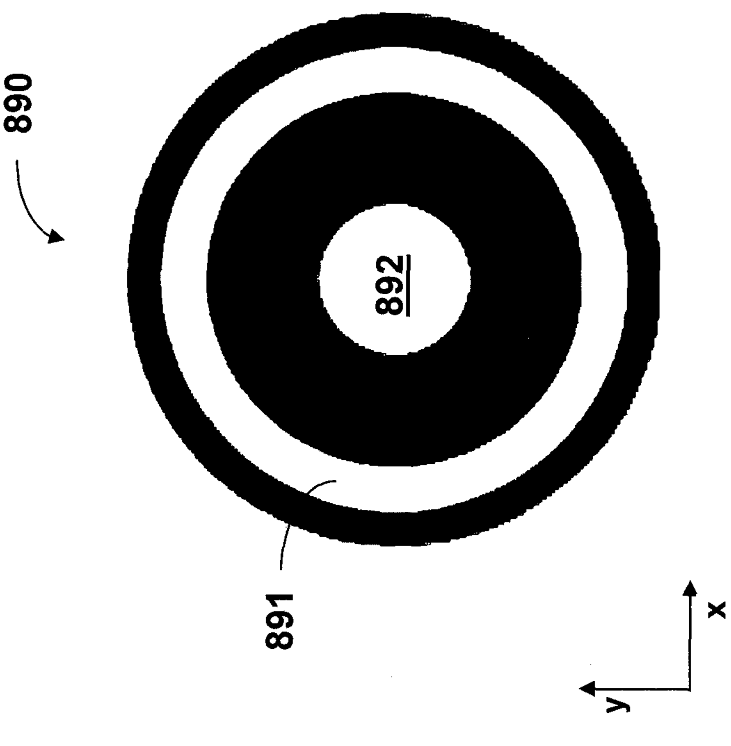


Fig. 10a

Fig. 11a

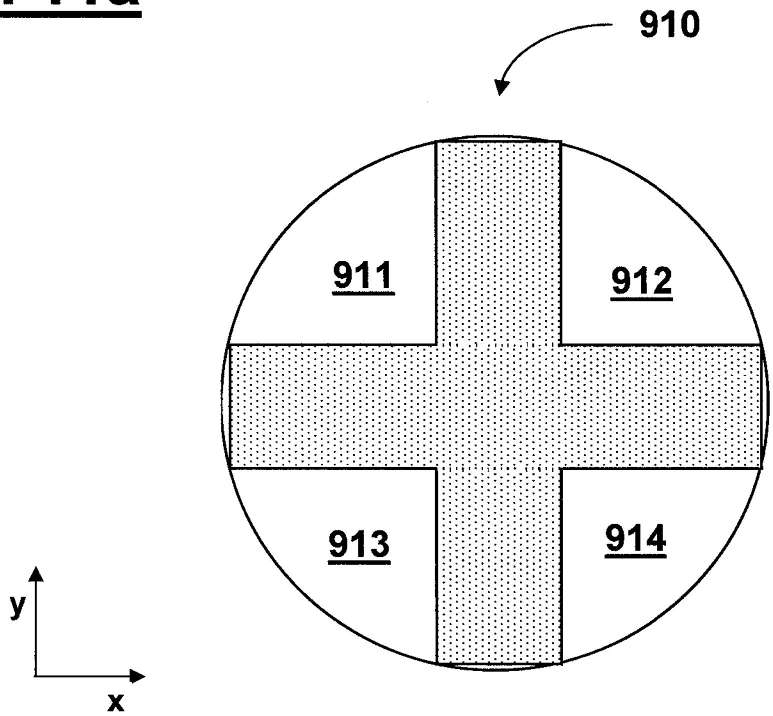


Fig. 11b

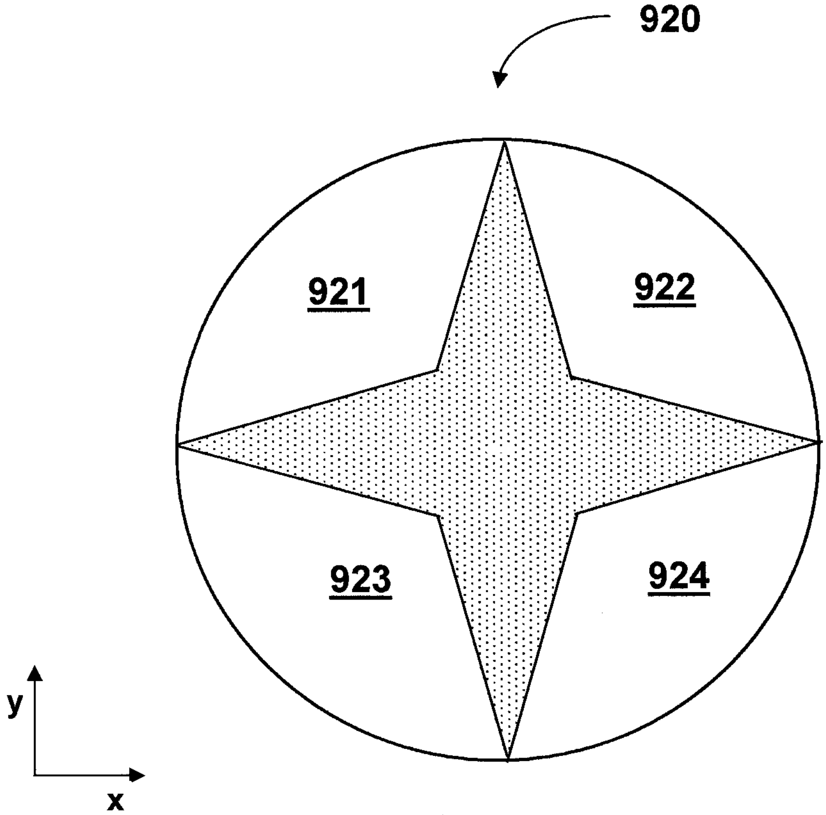


Fig. 11c

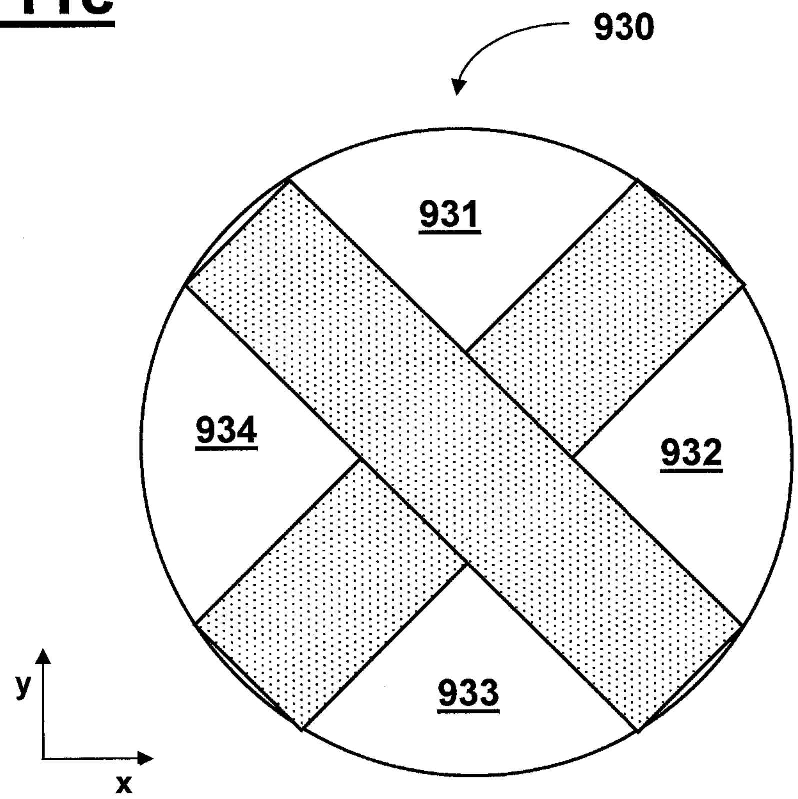
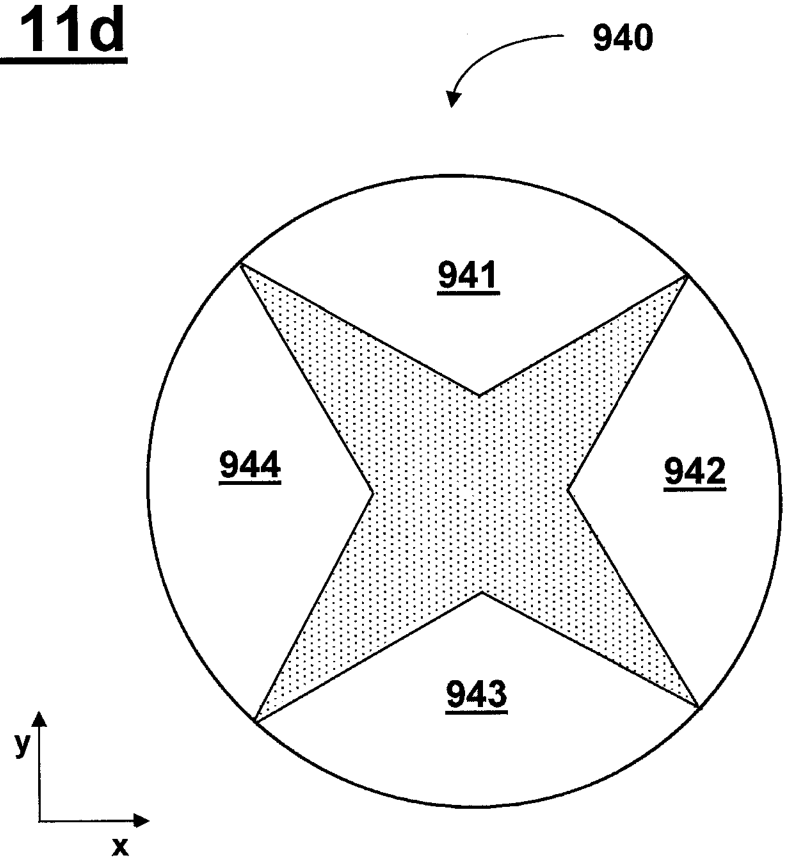


Fig. 11d



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/069308

A. CLASSIFICATION OF SUBJECT MATTER
INV. G03F7/20
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G03F G02B G21K

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

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

EPO-Internal, INSPEC, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DE 10 2008 041801 A1 (ZEISS CARL SMT AG [DE]; ASML NETHERLANDS BV [NL]) 4 March 2010 (2010-03-04) figure 1 abstract paragraphs [0030], [0033] -----	1,2,4,5, 8-13, 16-18, 20,22-24
Y	WO 03/093903 A2 (ZEISS CARL SMT AG [DE]; HOLDERER HUBERT [DE]; HEMBD-SOELLNER CHRISTIAN) 13 November 2003 (2003-11-13) figures 2,3,4 page 13, lines 2-5 page 14, line 30 - page 15, line 3 -----	1,2,4,5, 8-13, 16-18, 20,22-24

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search
23 December 2011

Date of mailing of the international search report
03/01/2012

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Menck, Alexander

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/069308

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 863 712 A (VON BUNAU RUDOLF MURAI [JP] ET AL) 26 January 1999 (1999-01-26) figures 6(a),6(b) column 9, lines 42-48 -----	1-24
A	DE 39 34 546 A1 (ZEISS CARL FA [DE]) 18 April 1991 (1991-04-18) column 3, lines 55-58 -----	1-24

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2011/069308

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
DE 102008041801	A1	04-03-2010	NONE			
WO 03093903	A2	13-11-2003	AU	2003224089	A1	17-11-2003
			DE	10220324	A1	13-11-2003
			EP	1504308	A2	09-02-2005
			JP	4398363	B2	13-01-2010
			JP	2005524237	A	11-08-2005
			US	2005146701	A1	07-07-2005
			US	2008143984	A1	19-06-2008
			WO	03093903	A2	13-11-2003
US 5863712	A	26-01-1999	JP	9199390	A	31-07-1997
			US	5863712	A	26-01-1999
DE 3934546	A1	18-04-1991	DE	3934546	A1	18-04-1991
			FR	2653184	A1	19-04-1991