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(54) Title: FACET MIRROR DEVICE

(57) Abstract: There is provided a facet mirror device (106.1) comprising a facet element (109) and a support unit (108), the support unit supporting the facet element (109) The support unit (108) comprises a first support element (108.1) and a second support element (108.2), the second support element (108.2) being connected to the facet element (109) to support the facet element (109). The first support element (108.1) is connected to the second support element (108.2) to support the second support element 108.2), the first support element (108.1) being connected to the second support element (108.1) via at least one flexure unit (108.4), the flexure unit (108.4) comprising at least one flexure (108.4).

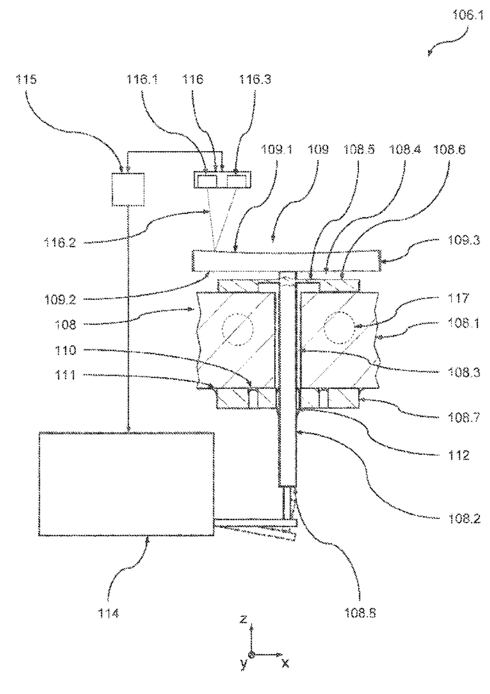


Fig. 3

FACET MIRROR DEVICE

BACKGROUND OF THE INVENTION

The invention relates to a facet mirror device that may be used within an optical device used in exposure processes, in particular in microlithography systems. It further relates to an optical imaging arrangement comprising such a facet mirror device. It further relates to a method of supporting a facet element of a facet mirror device and a method of manufacturing a facet mirror device. The invention may be used in the context of photolithography processes for fabricating microelectronic devices, in particular semiconductor devices, or in the context of fabricating devices, such as masks or reticles, used during such photolithography processes.

Typically, the optical systems used in the context of fabricating microelectronic devices such as semiconductor devices comprise a plurality of optical element modules comprising optical elements, such as lenses, mirrors, gratings etc., in the light path of the optical system. Those optical elements usually cooperate in an exposure process to illuminate a pattern formed on a mask, reticle or the like and to transfer an image of this pattern onto a substrate such as a wafer. The optical elements are usually combined in one or more functionally distinct optical element groups that may be held within distinct optical element units. Facet mirror devices as the ones mentioned above, among others may serve to homogenize the illumination light beam (illuminating the mask), i.e. to effect a power distribution within the illumination light beam which is as uniform as possible.

Due to the ongoing miniaturization of semiconductor devices there is not only a permanent need for enhanced resolution but also a need for enhanced accuracy of the optical systems used for fabricating those semiconductor devices. This accuracy obviously not only has to be present initially but has to be maintained over the entire operation of the optical system. A particular problem in this context is proper heat removal from the optical components to avoid uneven thermal expansion of these components leading to uneven deformation of these components and, ultimately, to undesired imaging errors.

As a consequence highly sophisticated facet mirror devices have been developed such as they are disclosed, for example, in DE 102 05 425 A1 (Holderer et al.) and DE 103 24 796 A1 (Roß-Meßemer), the respective entire disclosure of which is incorporated herein by reference.

Both these documents, among others, show facet mirror devices where facet elements with a spherical rear surface sit in an associated recess within a support element. The spherical rear surface rests against a corresponding spherical wall of the support element confining this recess. While such a sphere to sphere interface theoretically may provide a large area of contact with good heat transfer from the facet element to the support element, this large area contact mainly depends on the manufacturing accuracy of both, the facet element and the support element. Furthermore, the spherical recess is rather expensive to manufacture at an accuracy of a few microns or less as it is desirable in many cases in all three directions in space.

To overcome the problem of heat transfer DE 103 24 796 A1 (Roß-Meßemer) suggests to place a relatively soft coating (e.g. a gold coating) onto one of said spherical surfaces which compensates manufacturing tolerances by deformation. However, despite the low rigidity of this coating, due to the large contact area such deformation requires relatively large forces prone to introduce undesired deformation into the facet element.

Another approach is disclosed in DE 102 05 425 A1 (Holderer et al.) wherein the spherical rear surface of the facet element, more or less in a line contact, rests against a conical wall confining the recess receiving the facet element. This solution, due to the line contact provides a lower heat transfer while still not considerably reducing the manufacturing effort necessary for the conical wall to have the accuracy needed for properly positioning the facet element.

A third approach to support the facet elements is disclosed in DE 102 05 425 A1 (Holderer et al.) wherein the spherical rear surface of the facet element, more or less in a three point contact, rests against three small spheres each located at a free end of a support pin element. Here, the heat transfer is even worse while as well not considerably reducing the manufacturing effort necessary for the three small spheres to have the desired accuracy.

In all three cases outlined above, a manipulating lever is connected to the rear surface of the facet element, corresponding manipulators acting on said manipulating lever to adjust the position and, predominantly, the orientation of the facet element with respect to the support element. Furthermore, in some cases, the manipulating lever is used for fixing the facet element relative to the support element once it has bee adjusted,

SUMMARY OF THE INVENTION

It is thus an object of the invention to, at least to some extent, overcome the above disadvantages and to provide a simple way of supporting a facet element of a facet mirror device at a high accuracy, in particular an accuracy of a few microns or less.

It is a further object of the invention to allow easy adjustment and fixation of the facet element to the desired position and orientation with respect to the support element.

These and other objects are achieved according to the invention which, on the one hand, is based on the teaching that it is possible to provide a simple and reliable, easily adjustable support to the facet element if the facet element is supported via a flexure unit. Such a flexure unit may be easily manufactured while providing proper guidance to the facet element in one or more degrees of freedom allowing easy adjustment of the facet element in these degrees of freedom while reliably and precisely restricting motion in one or more other degrees of freedom.

Thus, according to a first aspect of the invention there is provided a facet mirror device comprising a facet element and a support unit, the support unit supporting the facet element. The support unit comprises a first support element and a second support element, the second support element being connected to the facet element to support the facet element. The first support element is connected to the second support element to support the second support element, the first support element being connected to the second support element via at least one flexure unit, the flexure unit comprising at least one flexure.

According to a second aspect of the invention there is provided an optical imaging arrangement comprising a mask unit adapted to receive a pattern, a substrate unit adapted to receive a substrate, an illumination unit adapted to illuminate the pattern, and an optical projection unit adapted to transfer an image of the pattern onto the substrate. At least one of the illumination unit and the optical projection unit comprises a facet mirror device, the facet mirror device comprising a facet element and a support unit, the support unit supporting the facet element. The support unit comprises a first support element and a second support element, the second support element being connected to the facet element to support the facet element. The first support element is connected to the second support element to support the second support element, the first support element being connected to the second support element via at least one flexure unit, the flexure unit comprising at least one flexure.

According to a third aspect of the invention there is provided a method of supporting a facet element of a facet mirror device comprising providing a facet element and a support element unit and supporting the facet element via the support unit. The support unit comprises a first support element and a second support element, the second support element being connected to the facet element to support the facet element. The first support element is connected to the second support element to support the second support element, the first support element being connected to the second support element via at least one flexure unit, the flexure unit comprising at least one flexure.

According to a fourth aspect of the invention there is provided a method of manufacturing a facet mirror device comprising, in a preparation step, providing a facet element and a support unit, the support unit comprising a first support element and a second support element, the first support element, to support the second support element, being connected to the second support element via at least one flexure unit, the flexure unit comprising at least one flexure; and, in a supporting step, connecting the facet element to the second support element to support the facet element via the support unit.

Further aspects and embodiments of the invention will become apparent from the dependent claims and the following description of preferred embodiments which refers to the appended figures. All combinations of the features disclosed, whether explicitly recited in the claims or not, are within the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1	is a schematic representation of a preferred embodiment of an optical imaging arrangement according to the invention which comprises a preferred embodiment of a facet mirror device according to the invention and with which preferred embodiments of methods according to the invention may be executed;
Figure 2	is a schematic top view of the facet mirror device of Figure 1;
Figure 3	is a schematic sectional representation of a part of the facet mirror device of Figure 1 and 2 (along line III-III of Figure 2);
Figure 4	is a block diagram of a preferred embodiment of a method of manufacturing a facet mirror device comprising a preferred embodiment of a method of supporting the facet element according to the invention which may be used for the optical imaging arrangement of Figure 1.

Figure 5	is a schematic sectional representation of a detail of a further preferred embodiment of a facet mirror device according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

First embodiment

In the following, a first preferred embodiment of an optical imaging arrangement 101 according to the invention will be described with reference to Figures 1 to 3. In order to facilitate the explanations given below an x,y,z-coordinate system has been introduced into the Figures and will be used throughout the following description. In the following, the z-direction designates the vertical direction. However, it will be appreciated that, with other embodiments of the invention, any other orientation in space of this x,y,z-coordinate system and the components of the optical imaging arrangement, respectively, may be chosen.

Figure 1 is a schematic and not-to-scale representation of the optical imaging arrangement in the form of an optical exposure apparatus 101 used in a microlithography process during manufacture of semiconductor devices. The optical exposure apparatus 101 comprises an illumination unit 102 and an optical projection unit 103 adapted to transfer, in an exposure process, an image of a pattern formed on a mask 104.1 of a mask unit 104 onto a substrate 105.1 of a substrate unit 105. To this end, the illumination unit 102 illuminates the mask 104.1. The optical projection unit 103 receives the light coming from the mask 104.1 and projects the image of the pattern formed on the mask 104.1 onto the substrate 105.1, e.g. a wafer or the like.

The illumination unit 102 comprises an optical element system 106 (only shown in a highly simplified manner in Figure 1) including a plurality of optical element units such as optical element unit 106.1. As will be explained in further detail below, the optical element unit 106.1 is formed as a preferred embodiment of a facet mirror device according to the invention. The optical projection unit 103 comprises a further optical element system 107 including a plurality of optical element units 107.1. The optical element units of the optical element systems 106 and 107 are aligned along a folded optical axis 101.1 of the optical exposure apparatus 101.

In the embodiment shown, the optical exposure apparatus 101 operates using light in the EUV range at a wavelength between 5 nm to 20 nm, more precisely at a wavelength of 13 nm. Thus, the optical elements used within the illumination unit 102 and the optical projection unit 103 are exclusively reflective optical elements. However, it will be appreciated that, with other embodiments of the invention working at different wavelengths, any type of optical elements (refractive, reflective or diffractive) may be used alone or in an arbitrary combination. The optical element system 107 may comprise a further facet mirror device according to the invention.

As can be seen from Figure 2 and 3, the facet mirror device 106.1 comprises a support unit 108 supporting a plurality of facet elements 109 (only one of which is shown in Figure 3). In the embodiment shown 900 facet elements 109 are supported on the support unit 108. However, it will be appreciated that, with other embodiments of the invention, at any other number of facet elements 109 may be carried by the support unit 108. For example, with certain preferred embodiments of the invention, up to 2000 facet elements 109 or even more are supported on the support unit 108. It should be noted that, preferably, as many facet elements 109 as possible are supported on the support unit 108 to obtain homogenization of the illumination light. Numbers of up to 4000 facet elements 109, more preferably, up to 16000 facet elements 109, may be realized.

In the embodiment shown, the facet elements 109 are arranged such that a small gap of less than 0.05 mm is left between them. Hence, as can be seen in particular from Figure 2, a regular rectangular matrix of facet elements 109 is formed on the support unit 108 providing a minimum amount of loss in radiant power. However, it will be appreciated that, with other embodiments of the invention, any other arrangement of facet elements may be chosen according to the optical needs of the imaging device, the facet mirror device is used for.

As can be further seen from Figure 2 and 3, in particular from Figure 2, each facet element 109, in a top view (along the z-direction), as an outer contour of substantially rectangular shape, more precisely of substantially squared shape. However, with other embodiments of the invention, any other geometry of this outer contour may be chosen such as, for example, an arbitrarily curved outer contour, a circular outer contour, an elliptic outer contour, a polygonal outer contour or arbitrary combinations thereof.

In the embodiment shown, each facet element has a concave front surface 109.1, a planar rear surface 109.2 and a lateral surface 109.3. The front surface 109.1 is a reflective surface optically used during operation of the optical imaging arrangement 101 in order to provide homogenization of the illumination light provided by the illumination unit 102. The reflective surface 109.1 may be provided via a reflective coating applied to the front surface 109.1 which is adapted to the wavelength of the illumination light used (typically, in order to provide maximum reflectivity at the respective wavelength). With certain embodiments of the invention a reflective grating may be provided at the front surface of the facet elements.

In the embodiment shown, the front surface 109.1 is a spherical surface. However, it will be appreciated that, with other embodiments of the invention, any other shape of the front surface may be chosen depending on the optical task to be performed by the facet mirror device. Hence, apart from such spherical surfaces, aspherical as well as planar surfaces as well as arbitrary combinations thereof may be used. Furthermore, convex front surfaces may also be used.

Furthermore, it should be noted that the optically usable front surface 109.1 of the facet element 109 may be of any suitable size. Preferably, the size of the front surface 109.1 ranges from 10 mm^2 to 400 mm^2, in particular from 50 mm^2 to 150 mm^2, more preferably from 90 mm^2 to 110 mm^2.

The support unit 108 comprises a first support element in the form of a base plate 108.1. Each facet element 109 has an associated second support element 108.2 which, in the embodiment shown, is a substantially pin-shaped body inserted into and reaching through an opening 108.3 within the base plate 108.1. In the embodiment shown, the opening 108.3 is a cylindrical bore. However, any other geometry may be chosen for this recess 108.3 within the base plate 108.1. Furthermore, in the embodiment shown, the base plate 108.1 is a planar element. However, depending e.g. on the optical requirements, an arbitrary geometry (e.g. an at least section wise curved geometry) may be chosen for the base plate.

One end of the second support element 108.2 is connected to the rear side 109.2 of the facet element 109 to support the latter. The second support element 108.2, in turn, is connected to the first support element 108.1 via a flexure unit 108.4 to support the second support element 108.2 and, consequently, the facet element 109 on the first support element 108.1.

The flexure unit 108.4 is located at the front side of the first support element 108.1 facing towards the facet element 109. The flexure unit 108.4 comprises a plurality of flexures in the form of leaf spring elements 108.5 connected at their ends to the second support element 108.2 and a ring-shaped linking section 108.6, respectively.

In the embodiment shown, four leaf spring elements 108.5 are evenly distributed at the circumference of the second support element 108.2. However, it will be appreciated that, with other embodiments of the invention, any other number of leaf spring elements or flexures may be provided. In particular, one single leaf spring element may also be provided connecting the linking section and the second support element in the manner of a continuous membrane extending over substantially the entire circumference of the second support element.

In the embodiment shown, each leaf spring element 108.5, in a top view (along the z-axis) is a substantially rectangular element. The transverse dimension of the leaf spring element 108.5 is selected such that (at the interface with the second support element 108.2) it extends over about 15% of the circumference of the second support element 108.2. However, it will be appreciated that, with other embodiments of the invention, any other suitable shape and dimensions may be selected for the leaf spring elements.

As can be seen from Figure 3, the leaf spring elements 108.5 are formed monolithic with the second support element 108.2 and the linking section 108.6, while the linking section 108.6 is connected to the first support element 108.1 by any suitable connection (not shown in greater detail) such as a positive connection, a frictional connection, an adhesive connection or arbitrary combinations thereof. However, it will be appreciated that, with other embodiments of the invention, the linking section may also be formed monolithic with the first support element. The same applies the other way round two the connection between the leaf spring elements and the second support element.

The second support element 108.2 protrudes from the rear side of the first support element 108.1 facing away from the facet element 109. Here, in the mounted state (shown in Figure 3), the first support element 108.1 and the second support element 108.2 are substantially rigidly connected via a connector element in the form of a connector plate 108.7. The connector plate 108.7 is locking the first support element 108.1 and the second support element 108.2 in their mutual relative position and orientation. Hence, the connector plate 108.7 also takes part in supporting the facet element 109.

The connector plate 108.7 is connected to the first support element 108.1 and the second support element 108.2 by any suitable connection such as a positive connection, a frictional connection, an adhesive connection or arbitrary combinations thereof. Preferably, the respective connection is formed by an adhesive connection such as by gluing, soldering or welding as it indicated by the contours 110, 111 and 112.

As will be explained now in greater detail with reference to Figures 2 to 4 the facet mirror device 106.1 is manufactured according to a preferred embodiment of the method according to invention using a preferred embodiment of the method of supporting a facet element according to the invention.

According to Figure 4, in a preparation step 113.1, the components of the support unit 108 and the facet elements 109 are manufactured as it has been outlined above. In the embodiment shown, the facet elements are made of silicon (Si), while the support element is made of silicon carbide (SiC). With such a material pairing and beneficial heat transfer from the facet elements 109 (typically reaching temperatures of 100°C to 150°C during operation of the imaging arrangement 101) may be obtained.

However, it will be appreciated that, with other embodiments of the invention, the facet element may be made of silicon carbide (SiC), quartz (SiO_2), silicon aluminium (SiAl) Zerodur® (a glass ceramic as manufactured by SCHOTT AG, Mainz, DE), ULE™ (ultra low expansion titanium silicate glass as manufactured by Corning Incorporated, Corning, NY 14831, USA), other glass ceramics as well as copper (Cu) or aluminium (Al) coated with N1P or MoSi layers; while the support element may be made of stainless steel, copper (Cu), aluminium (Al), reaction bonded silicon infiltrated silicon carbide (SiSiC), Zerodur® or other glass ceramics. It should be noted that, preferably, a matching of the coefficient of thermal expansion (CTE) is provided for the facet element and the support element.

Then, in a connecting step 113.3 of a supporting step 113.2, the second support element 108.2 is introduced into the opening 108.3 until the linking section 108.4 rest against the run-on surface of the first support element 108.1. Subsequently, the linking section 108.4 is connected to the first support element 108.1 as it has been outlined above.

Then, the facet element 109 is connected to the second support element 108.2 by any suitable connection (not shown in greater detail) such as a positive connection, a frictional connection, an adhesive connection or arbitrary combinations thereof. However, it will be appreciated that, with other embodiments of intervention, the facet element 109 may be connected to the second support element 108.2 prior to connecting the latter to the first support element 108.1.

Then, in an adjustment step 113.4 of the supporting step 113.2, the position and orientation of the facet element 109 with respect to the first support element 108 is adjusted according to the optical requirements for the facet mirror device 106.1 during later operation in the imaging arrangement 101.

To this end, an adjustment device in the form of a manipulator 114 controlled by a control device 115 is used to generate a corresponding adjustment force on an adjustment interface 108.8 of the second support element 108.2 as it is shown in Figure 3. Under the control of the control device 115 a relative motion may be generated between the manipulator 114 and the facet mirror device 106.1 is such that the manipulation force F generated may induce the appropriate adjustment motion to provide proper adjustment of the latter.

It will be appreciated that the leaf spring elements 108.5 of the flexure unit 108.4 provide guidance to the second support element 108.2 and facet element 109 by restricting relative motion in two translational degrees of freedom (namely the x- and y-direction) and one rotational degree of freedom (namely rotation about the z-axis) while allowing orientation adjustment in two rotational degrees of freedom (namely rotation about the x- and y-axis) and position adjustment in one translational degree of freedom (namely the z-direction). Hence, in a very simple manner, proper height and inclination adjustment of the facet element 109 may be achieved.

It will be further appreciated that, with certain embodiments of the invention, the manipulator 114 may also be used to adjust the rotation of the facet element 109 (then already mounted to the second support element 108.2) about the z-axis prior to connecting the linking section 108.4 of the second support element 108.2 to the first support element 108.1.

Assessment of the adjustment of the optically used front surface 109.1 is performed using the measurement results of a measurement device 116. In the present embodiment, the measurement device 116 is an optical device comprising an emitter 116.1 emitting a measurement light beam 116.2 towards the front surface 109.1. The measurement light beam 116.2 is reflected at the front surface 109.1 and reaches a sensor 116.3 of the measurement device 116.

In the embodiment shown, the emitter is a conventional emitter using measurement light at a wavelength of 633 nm. Hence, it may be necessary to provide a measurement section at the front surface 109.1 having a reflective coating adapted to this wavelength of the measurement light (provided that the reflective coating of the front surface 109.1 adapted to the exposure light does not provide sufficient reflection at the measurement light wavelength). However, it will be appreciated that, with other embodiments of the invention, other wavelengths may be used for the measurement light, such that, eventually, no such additional measurement section may be necessary.

The signals of the sensor 116.3 are forwarded to the control device 115 which, in turn, performs the assessment of the adjustment of the front surface 109.1 using these signals. It will be appreciated that the control device 115, as a function of the signals of the sensor 116.3, controls the manipulator 114 to provide rapid proper adjustment of the front surface 109.1.

It will be appreciated that, in the embodiment shown, the front surface 109.1 is adjusted at an angular accuracy of less than 100 µrad. However, it will be appreciated that, with other embodiments of the invention, depending on the optical requirements during later operation of the imaging arrangement 101, any other angular accuracy may be chosen.

Once the adjustment of the facet element 109 is completed, in a facet fixation step 113.5 of the supporting step 113.2, the facet element 109 is fixed in place by connecting the connector plate 108.7 to the second support element 108.2 as it has been outlined above.

In the present example, a laser welding technique is used to provide the fixed adhesive connection 112 between the connector plate 108.7 and the second support element 108.2. However, it will be appreciated that, with other embodiments of the invention, apart from the laser welding technique as outlined above, any other suitable bonding technique (such as e.g. fusion bonding, gluing, clamping etc.) may be used alone or in arbitrary combination to provide proper connection and relative fixation between the facet elements and the support unit. Such suitable bonding techniques include, for example, gluing, soldering, laser soldering, welding, diffusion bonding etc.

The connector plate 108.7 had been connected to the first support element 108.1 prior to the adjustment step. However, it will be appreciated that, with other embodiments of the invention, the connection between the connector plate 108.7 and the first support element 108.1 may also be applied at any point in time during or after the adjustment of the facet element as it has been outlined above.

Once the facet fixation step 113.5 is completed, the manipulator 114 disengages the adjustment interface 108.8 of the second support element 108.2 as it is indicated by the dashed contour in Figure 3.

In a step 113.6 it is then checked if a further facet element 109 is to be mounted to the support element 108. If this is the case the method jumps back to step 113.3 for executing the supporting step for the next facet element 109 to be mounted. Otherwise, the method ends in step 113.7.

Heat removal from the facet mirror device 106.1 during operation of the imaging arrangement 101 may be achieved using a cooling medium circulating through cooling channels as they are indicated by the dashed contours 117 (see Figure 3).

The connection between the first support element 108.1 and the second support element 208.2 may be made in a sealing manner such that, during operation of the facet mirror device 106.1, the rear side of the base body 108 (facing away from the facet elements 109) may be cooled by a fluid, e.g. a cooling medium, while the space surrounding the facet elements 109 is evacuated (or, depending on the wavelength of the illumination light, eventually filled with a gas). This may be achieved in a particularly simple manner in specific embodiments where one single leaf spring element is provided connecting the linking section and the second support element in the manner of a continuous membrane extending over the entire circumference of the second support element as it has been described above.

In the embodiment shown, the flexure unit comprises flexure is in the form of a leaf spring elements. However, it will be appreciated that, with other embodiments of the invention, other types of flexure is maybe used. For example, instead of a leaf spring element, configuration may be used comprising two elastic hinges each formed at one end of a less flexible section. For example, the leaf springs 108.5 could be replaced by such a configuration, one elastic hinge being formed at the transition to the linking section 108.6 and the other elastic hinge being formed at the transition to the second support element 108.2.

Second embodiment

In the following, a second embodiment of the facet mirror device 206.1 according to the invention will be described with reference to Figure 5. The facet mirror device 206.1 in its basic design and functionality largely corresponds to the facet mirror device 106.1 and may replace the facet mirror device 106.1 in the optical imaging device 101 of Figure 1. In particular, the method of supporting a facet element and the method of manufacturing the facet mirror device as they have been described above in relation to the first embodiment (Figure 4) may be executed as well in the context of this facet mirror device 206.1. Thus, it is here mainly referred to the explanations given above and only the differences with respect to the facet mirror device 106.1 will be explained in further detail. In particular, similar parts are given the same reference numeral raised by the amount 100 and (unless explicitly described in the following) in respect to these parts reference is made to the explanations given above in the context of the first embodiment.

The only main difference with respect to the facet mirror device 106.1 lies within the design of the flexure unit 208.4. In the embodiment shown, the flexure unit 208.4 is formed by suitable generally ring-shaped slots (connected over certain parts of the circumference of the second support element 208.2 by radial slots) within the base body 208, thereby forming a plurality of (preferably evenly distributed) leaf spring elements 208.5. Elastic hinges 208.9 may be formed at at least one end of the respective leaf spring element 208.5 to facilitate orientation adjustment. It will be appreciated that the flexure unit 208.4 allows motion in two rotational degrees of freedom (namely rotation about the x- and y-axis) while restricting motion in all other four degrees of freedom.

The connection between the connector element 208.7 and the first support element 208.1 and the second support element 208.2 is made in a sealing manner such that a cavity 218 at the rear side of the base body 208 may be filled with a cooling medium while the space surrounding the facet elements 209 is evacuated.

In the foregoing, the invention has been described in the context of embodiments where the optical module according to the invention is used in the illumination unit. However, it will be appreciated that the optical module according to the invention may provide its beneficial effects as well in the optical projection unit.

In the foregoing, the invention has been described in the context of embodiments working in the EUV range. However, it will be appreciated that the invention may also be used at any other wavelength of the exposure light, e.g. in systems working at 193 nm etc.

Finally, in the foregoing, the invention has been described solely in the context of microlithography systems. However, it will be appreciated that the invention may also be used in the context of any other optical device using facet mirror devices.

* * * * *

What is claimed is:

1. A facet mirror device comprising
   - a facet element and
   - a support unit;
   - said support unit supporting said facet element;
   - said support unit comprising a first support element and a second support element;
   - said second support element being connected to said facet element to support said facet element;
   - said first support element being connected to said second support element to support said second support element;
   - said first support element being connected to said second support element via at least one flexure unit, said flexure unit comprising at least one flexure.

2. The facet mirror device according to claim 1, wherein at least one of
   - said flexure unit forms a guiding unit adapted to guide said facet element in an adjustment motion;

   and

   - said flexure unit restricts relative motion between said first support element and said second support element in at least two degrees of freedom;

   and

   - said flexure unit restricts relative motion between said first support element and said second support element in exactly three degrees of freedom;

   and

   - said flexure unit restricts relative motion between said first support element and said second support element in two translatory degrees of freedom and one rotatory degree of freedom.

3. The facet mirror device according to claim 1, wherein
   - said flexure unit restricts relative motion between said first support element and said second support element in two translatory degrees of freedom;

- said flexure unit comprising at last one flexure element mainly extending in a plane defined by said two translatory degrees of freedom.

4. The facet mirror device according to claim 1, wherein at least one of

- said flexure unit comprises at least one elastic hinge element;

and

- said flexure unit comprises at least one leaf spring element.

and

- said flexure unit comprises at least one membrane element.

5. The facet mirror device according to claim 1, wherein at least one of

- said flexure unit is formed monolithic with said first support element;

and

- said flexure unit is formed monolithic with said second support element.

-

6. The facet mirror device according to claim 1, wherein at least one of

- said second support element has an adjustment interface, said adjustment interface being adapted to be contacted by an adjustment device adjusting at least one of a relative position and a relative orientation between said facet element and said support unit;

and

- said second support element extends within a recess of said first support element;

and

- said second support element extends through an opening within said first support element; an adjustment interface for an adjustment device being formed at a rear end of said second support element facing away from said facet element.

7. The facet mirror device according to claim 1, wherein at least one of

- said first support element and said second support element are connected via a connector element;

and

- said first support element and said second support element are connected in at least one of a sealing manner and a fluid tight manner;

and

- said second support element extends through an opening within said first support element, a connector element connecting said first support element and said second support element being located at a rear side of said first support element facing away from said facet element;

and

- said connector element is connected to at least one of said first support element and said second support element by an adhesive bond;

and

- said connector element is connected to at least one of said first support element and said second support element by at least one bonding technique selected from a group of bonding techniques consisting of gluing, soldering, laser soldering, welding, laser welding, diffusion bonding.

8. The facet mirror device according to claim 1, wherein at least one of

- said facet element is connected to said second support element by an adhesive bond;

and

- said facet element is connected to said second support element by at least one bonding technique selected from a group of bonding techniques consisting of gluing, soldering, laser soldering, welding, laser welding, diffusion bonding.

9. The facet mirror device according to claim 1, wherein at least one of

- said support unit comprises at least one cooling duct adapted to receive a cooling medium during operation of said facet mirror device;

and

- a cooling cavity is formed at a rear side of said first support element facing away from said facet element; said cooling cavity being adapted to be filled, at least during operation of said facet mirror device, with a cooling medium.

10. The facet mirror device according to claim 1, wherein at least one of

- said support unit comprises a plurality of further second support sections, each of said further second support sections being connected to said first support element and supporting a further facet element;

and

- said support unit supports at least 1000 facet elements.

11. An optical imaging arrangement comprising

- a mask unit adapted to receive a pattern,
- a substrate unit adapted to receive a substrate;
- an illumination unit adapted to illuminate said pattern;
- an optical projection unit adapted to transfer an image of said pattern onto said substrate;
- at least one of said illumination unit and said optical projection unit comprising a facet mirror device,
- said facet mirror device comprising a facet element and a support unit;
- said support unit supporting said facet element;
- said support unit comprising a first support element and a second support element;
- said second support element being connected to said facet element to support said facet element;
- said first support element being connected to said second support element to support said second support element;
- said first support element being connected to said second support element via at least one flexure unit, said flexure unit comprising at least one flexure.

12. A method of supporting a facet element of a facet mirror device comprising

- providing a facet element and a support element unit;
- supporting said facet element via said support unit;
- said support unit comprising a first support element and a second support element;
- said second support element being connected to said facet element to support said facet element;

- said first support element being connected to said second support element to support said second support element;
- said first support element being connected to said second support element via at least one flexure unit, said flexure unit comprising at least one flexure.

13. A method of manufacturing a facet mirror device comprising,

- in a preparation step, providing a facet element and a support unit, said support unit comprising a first support element and a second support element, said first support element, to support said second support element, being connected to said second support element via at least one flexure unit, said flexure unit comprising at least one flexure; and,
- in a supporting step, connecting said facet element to said second support element to support said facet element via said support unit.

14. The method according to claim 13, wherein at least one of,

- in a facet adjustment step of said supporting step, an adjustment of at least one of a position and an orientation of said facet element with respect to said support unit is performed according to optical needs during operation of said facet mirror device

and

- in a facet adjustment step of said supporting step, using an adjustment device contacting an adjustment interface of said second support element to adjust at least one of a position and an orientation of said facet element with respect to said support unit;

and

- in a facet adjustment step of said supporting step, using said flexure unit to guide said facet element in an adjustment motion adjusting at least one of a position and an orientation of said facet element with respect to said support unit.

15. The method according to claim 13, wherein, in a facet fixation step of said supporting step, at least one of

- fixing said facet element with respect to said support unit;

and

- connecting said first support element and said second support element in at least one of a sealing manner and a fluid tight manner;

and

- connecting said first support element and said second support element via a connector element;

and

- connecting said first support element and said second support element via a connector element, said second support element extending through an opening within said first support element, said connector element being located at a rear side of said first support element facing away from said facet element;

and

- connecting a connector element to at least one of said first support element and said second support element by an adhesive bond;

and

- connecting a connector element to at least one of said first support element and said second support element by at least one bonding technique selected from a group of bonding techniques consisting of gluing, soldering, laser soldering, welding, laser welding, diffusion bonding.

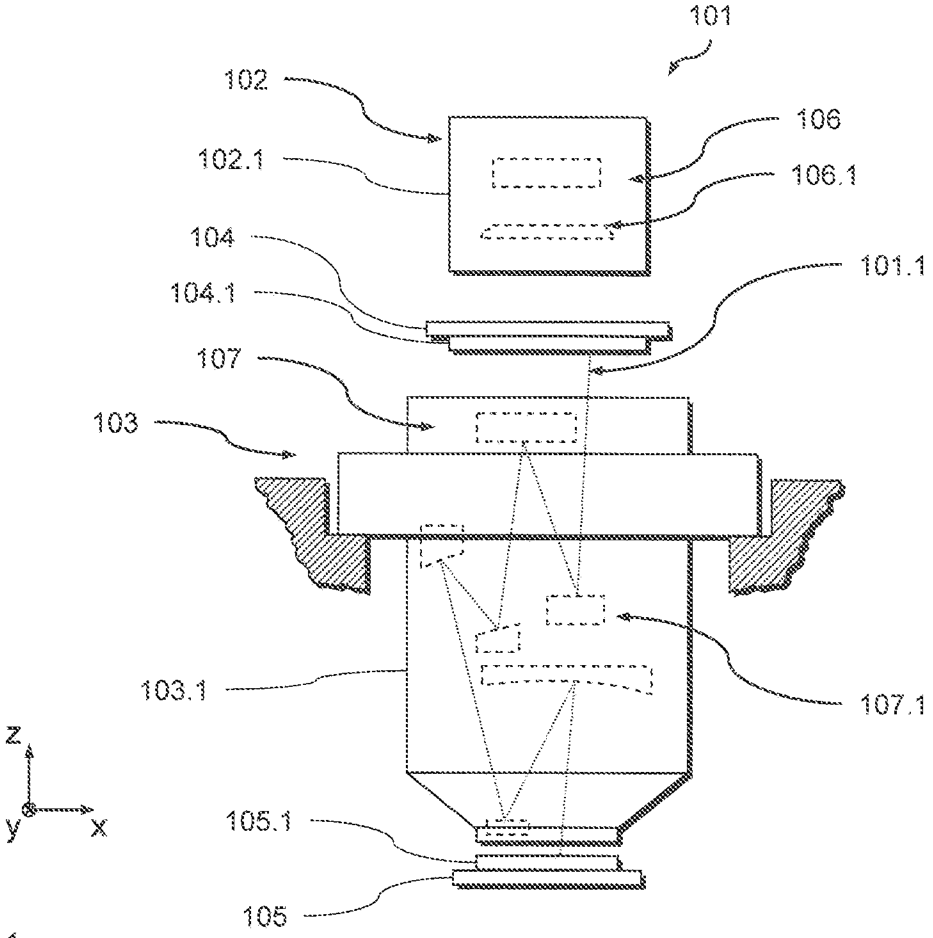
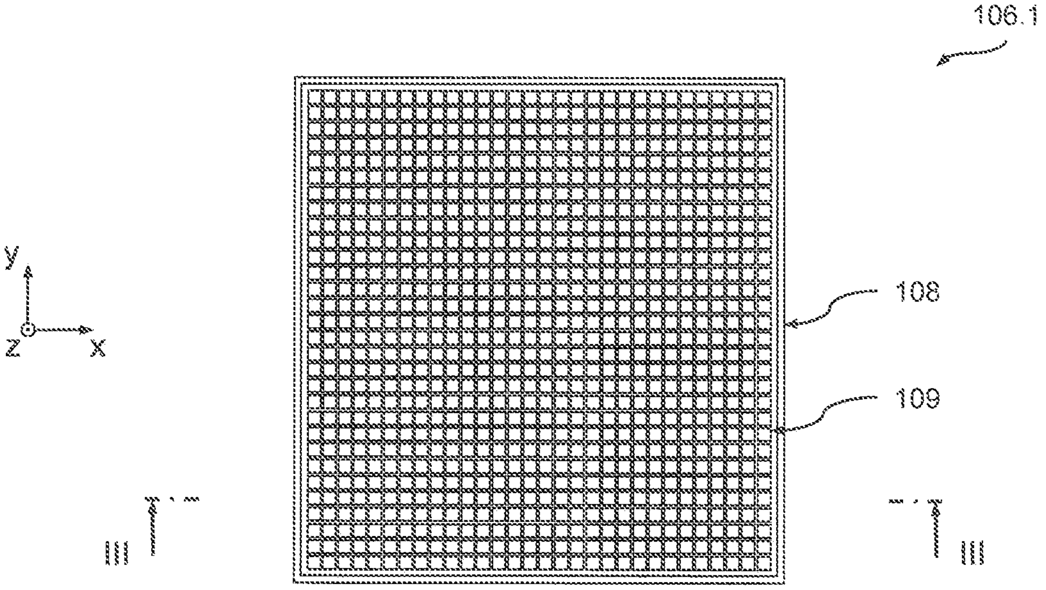

101
102
102.1
106
106.1
104
104.1
101.1
107
103
103.1
107.1
z
y
x
105.1
105

Fig. 1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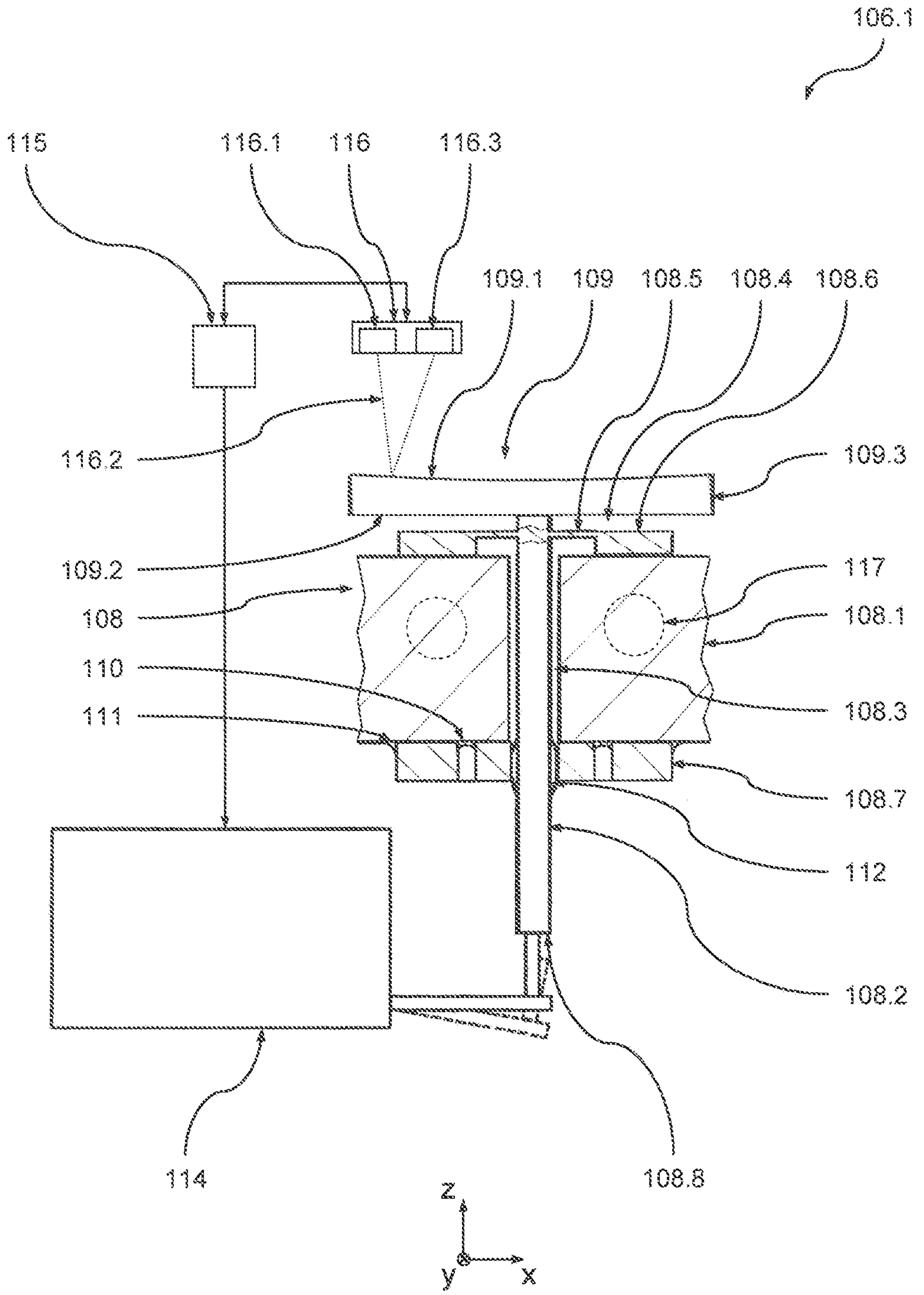
y
z
x
108
109
III
III

Fig. 2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116.1
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116.3
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108
108.1
110
108.3
111
108.7
112
108.2
114
108.8
z
y
x

Fig. 3

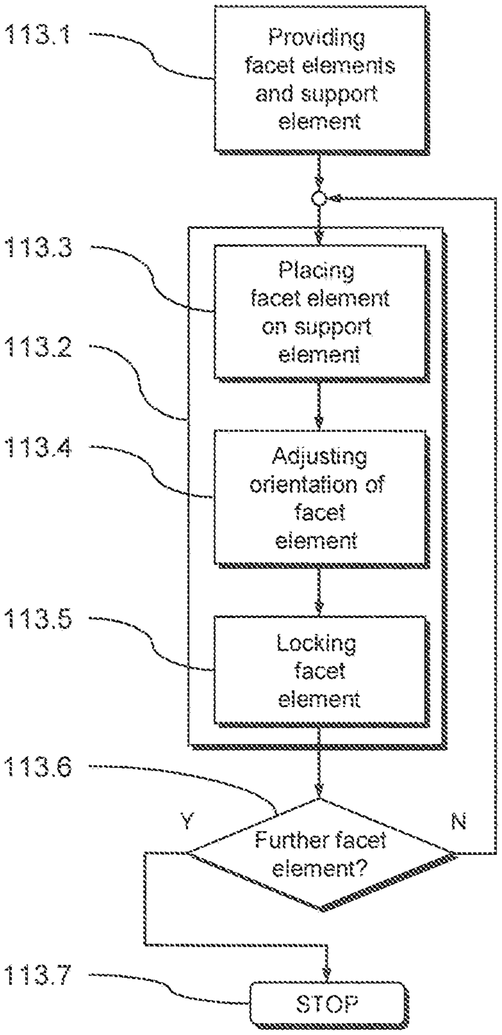
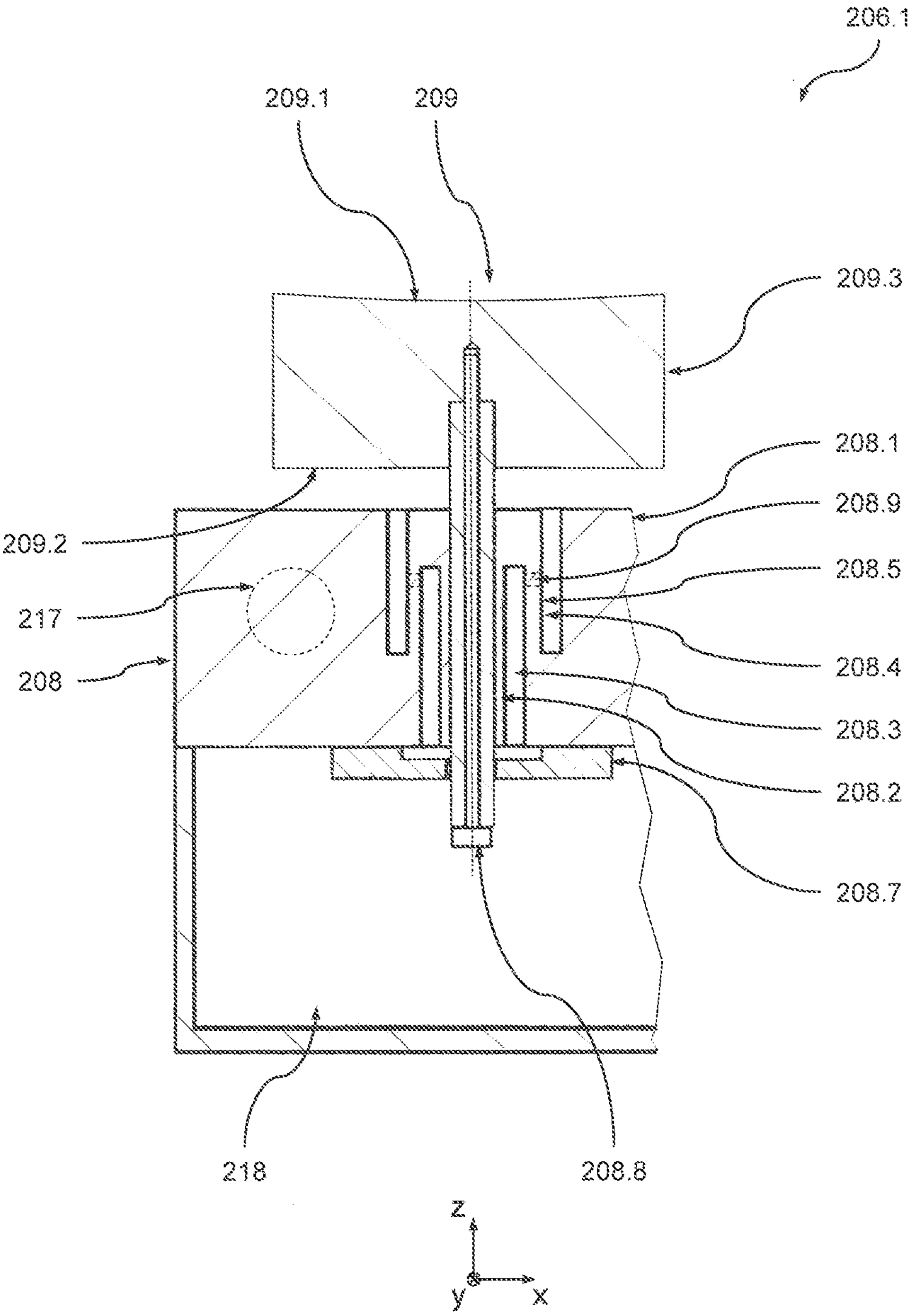

113.1
Providing facet elements and support element
113.3
Placing facet element on support element
113.2
113.4
Adjusting orientation of facet element
113.5
Locking facet element
113.6
Y
N
Further facet element?
113.7
STOP

Fig. 4


206.1
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209
209.3
208.1
208.9
208.5
209.2
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208.3
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208.7
218
208.8
z
y
x

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/055938

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

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G03F H01L G02B

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

Electronic data base consulted during the international search (name of data base and, where 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.
X	WO 2010/049076 A2 (ZEISS CARL SMT AG [DE]; HAUF MARKUS [DE]; WALDIS SEVERIN [DE]; NOELL W) 6 May 2010 (2010-05-06) page 28, lines 13-21 page 29, lines 9-11 page 32, lines 2-7 figures 5,11 -----	1-13
X	WO 2009/100856 A1 (ZEISS CARL SMT AG [DE]; DINGER UDO [DE]; ENDRES MARTIN [DE]; WERBER AR) 20 August 2009 (2009-08-20) abstract figures 31-34 page 43, line 27 - page 46, line 6 ----- -/--	1-13

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search 7 September 2011	Date of mailing of the international search report 22/09/2011
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Menck, Alexander

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/055938

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2008/131930 A1 (ZEISS CARL SMT AG [DE]; FISCHER JUERGEN [DE]; BENZ DANIEL [DE]; STACKL) 6 November 2008 (2008-11-06) abstract page 23, line 9 - page 24, line 5 figure 9b -----	1-13

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2011/055938

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		EP 2243047 A1	27-10-2010
		JP 2011512659 A	21-04-2011
		KR 20100126370 A	01-12-2010
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WO 2008131930 A1	06-11-2008	NONE	