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(54) **METHOD AND DEVICE FOR IRRADIATING SPOTS ON A LAYER**

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(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,648,587 A * 3/1972 Stevens G03B 3/02 355/44
4,480,910 A * 11/1984 Takanashi et al. ... G03F 7/2041 355/30
(Continued)

FOREIGN PATENT DOCUMENTS

DE 206607 2/1984
DE 221 563 A1 * 4/1984
(Continued)

OTHER PUBLICATIONS

English Translation of WO 49504 (dated Sep. 30, 1999).*
(Continued)

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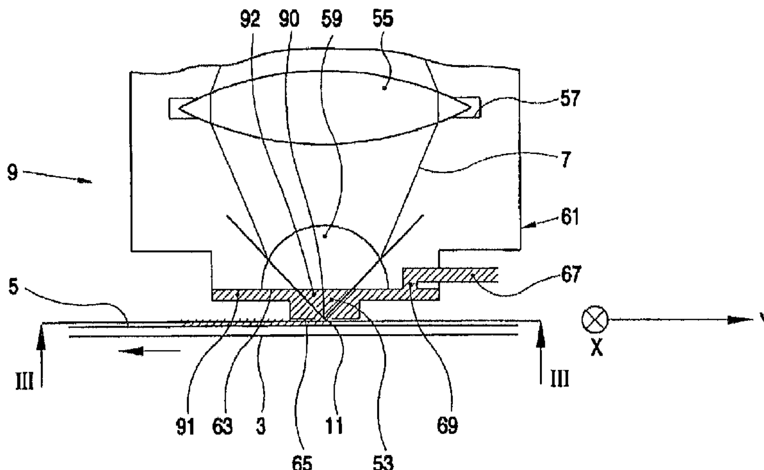
(57) **ABSTRACT**

For irradiating a layer a radiation beam is directed and focussed to a spot on the layer, relative movement of the layer relative to the lens is caused so that, successively, different portions of the layer are irradiated and an interspace between a surface of the lens nearest to the layer is maintained. Furthermore, at least a portion of the interspace through which the radiation irradiates the spot on the layer is maintained filled with a liquid, the liquid being supplied
(Continued)



via a supply conduit. At least a portion of the liquid fills up a recess through which the radiation irradiates the spot.

20 Claims, 5 Drawing Sheets

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G03C 5/00	(2006.01)
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G03F 7/20	(2006.01)
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(56) **References Cited**

U.S. PATENT DOCUMENTS

4,704,348	A	11/1987	Koizumi et al.	
5,121,256	A *	6/1992	Corle	B82Y 10/00 250/492.2
5,610,683	A *	3/1997	Takahashi	355/53
5,825,043	A	10/1998	Suwa	
6,000,996	A	12/1999	Fujiwara	
6,104,687	A *	8/2000	Lee et al.	369/112.24
6,191,429	B1	2/2001	Suwa	
6,649,093	B2	11/2003	Van Santen et al.	
6,788,477	B2 *	9/2004	Lin	G03F 7/70341 359/819
6,867,844	B2	3/2005	Vogel et al.	
6,952,253	B2	10/2005	Lof et al.	
6,954,256	B2	10/2005	Flagello et al.	
6,970,228	B1 *	11/2005	Aoki	G03F 7/70225 355/30
7,009,682	B2	3/2006	Bleeker	
7,061,578	B2	6/2006	Levinson	
7,075,616	B2	7/2006	Derksen et al.	
7,081,943	B2	7/2006	Lof et al.	
7,193,232	B2	3/2007	Lof et al.	
7,199,858	B2	4/2007	Lof et al.	
7,234,477	B2	6/2007	De Larios et al.	
7,358,507	B2	4/2008	Van Santen	
7,416,281	B2	8/2008	Nishimura et al.	
7,436,486	B2	10/2008	Hirukawa	
2001/0037819	A1	11/2001	Mitsumori et al.	
2002/0020821	A1 *	2/2002	Van Santen et al.	250/492.2

FOREIGN PATENT DOCUMENTS

DE	221563		4/1985	
DE	221563	A1 *	4/1985	
JP	59-019912	A	2/1984	
JP	6-124873	*	5/1994	
JP	H10-255319		9/1998	
JP	2000-58436		2/2000	
WO	WO 99/49504	*	9/1999	
WO	WO-9949504	*	9/1999	G03F 7/70241

OTHER PUBLICATIONS

English Translation of DD 221 563 A) (dated Apr. 24, 1985).*
English Translation of WO 99/49504 (dated Sep. 30, 1999).*
English Translation of JP 6-124873 (dated May 6, 1994).*
English Translation of DD 221 563 A1 (dated Apr. 24, 1985).*

* cited by examiner

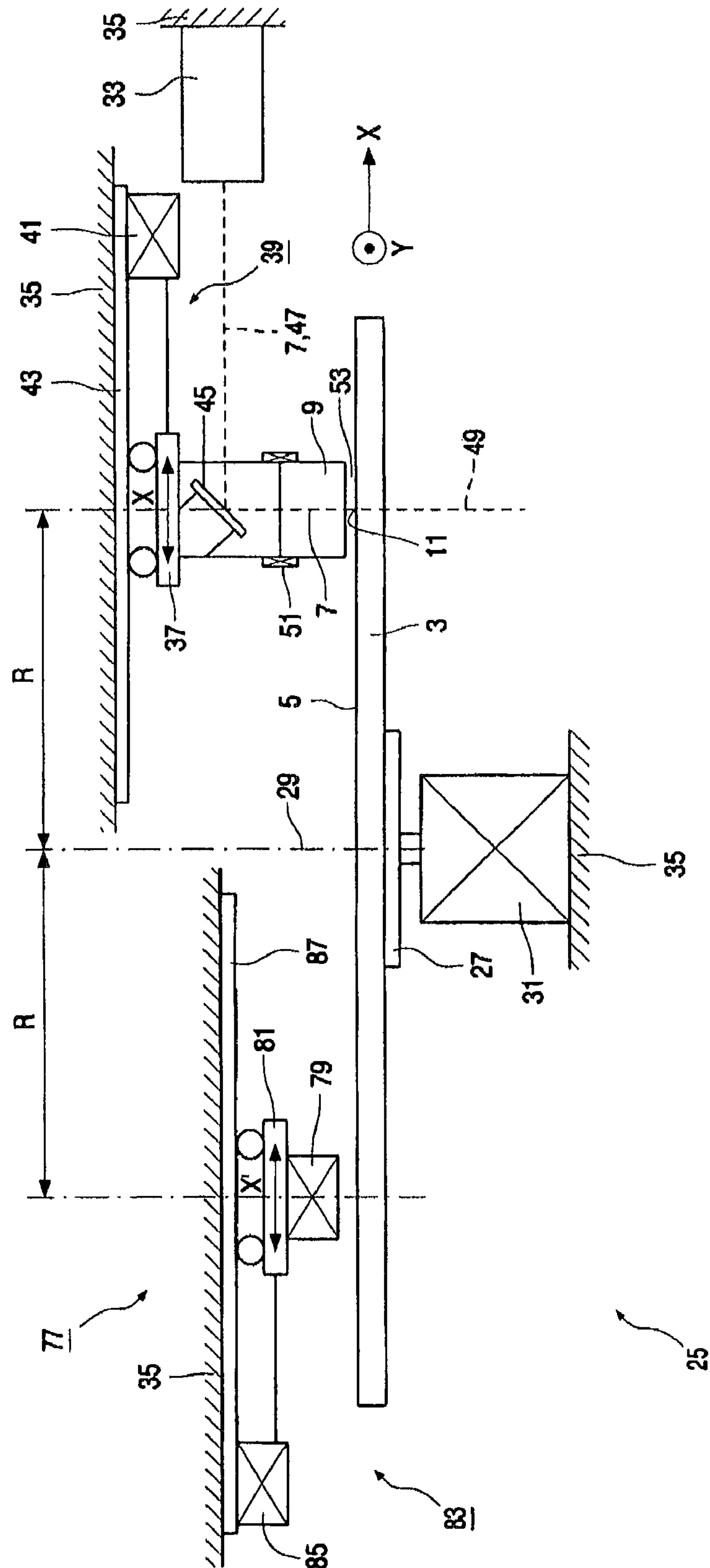

FIG. 1

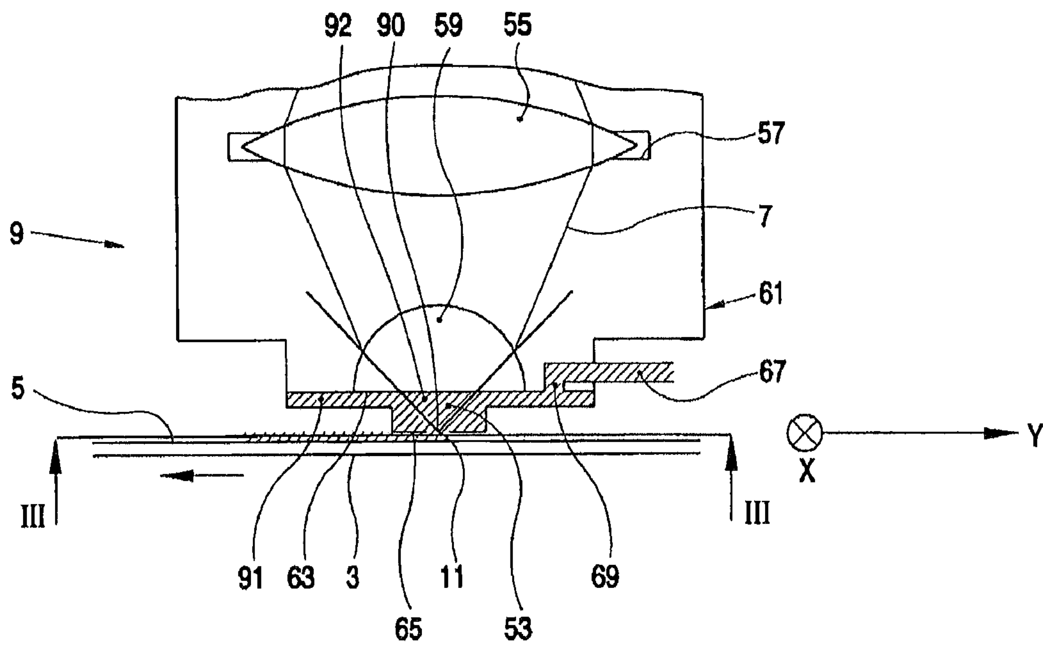

FIG. 2

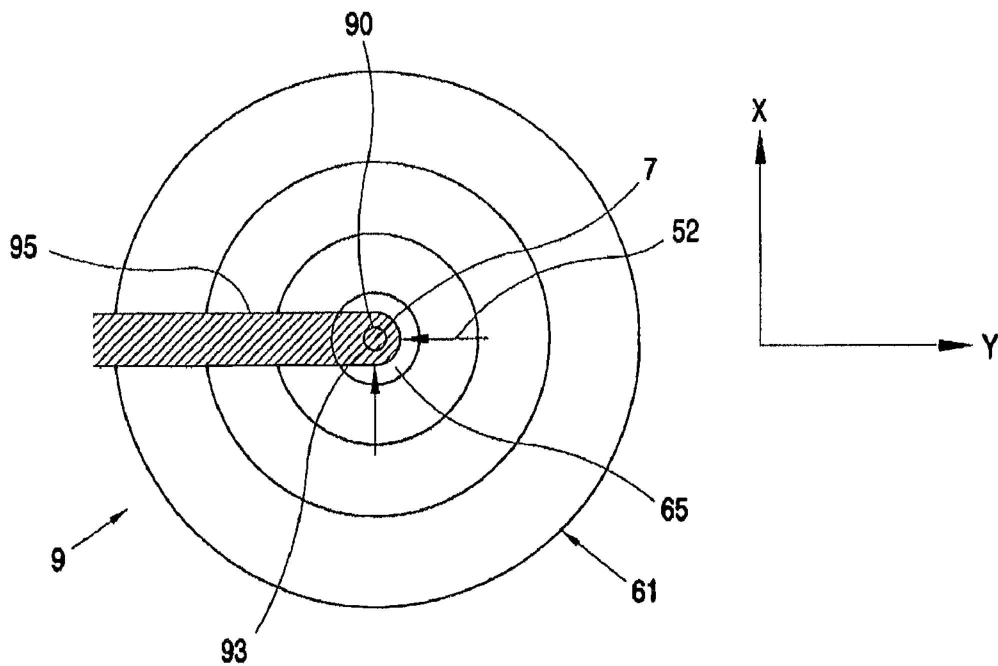

FIG. 3

FIG. 4

FIG. 5

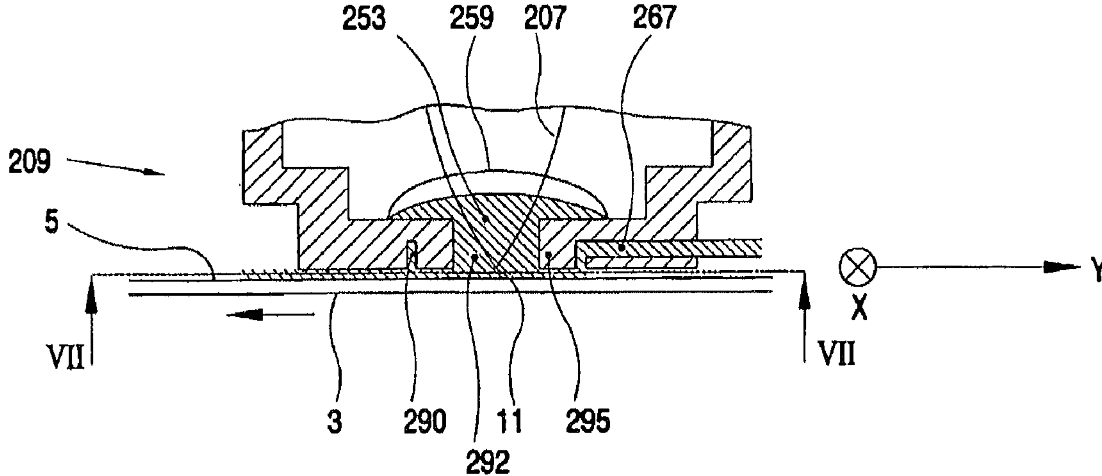

FIG. 6

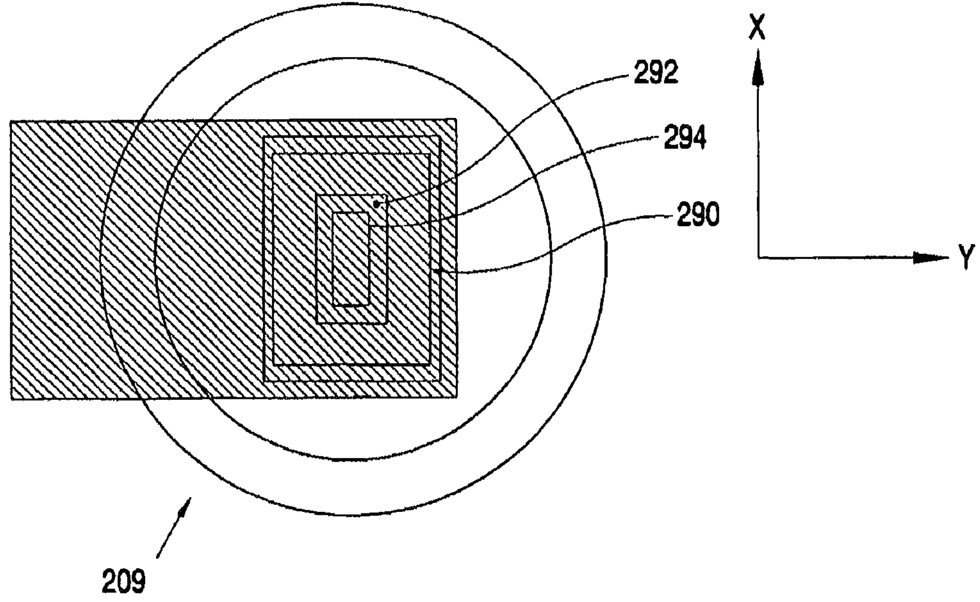

FIG. 7

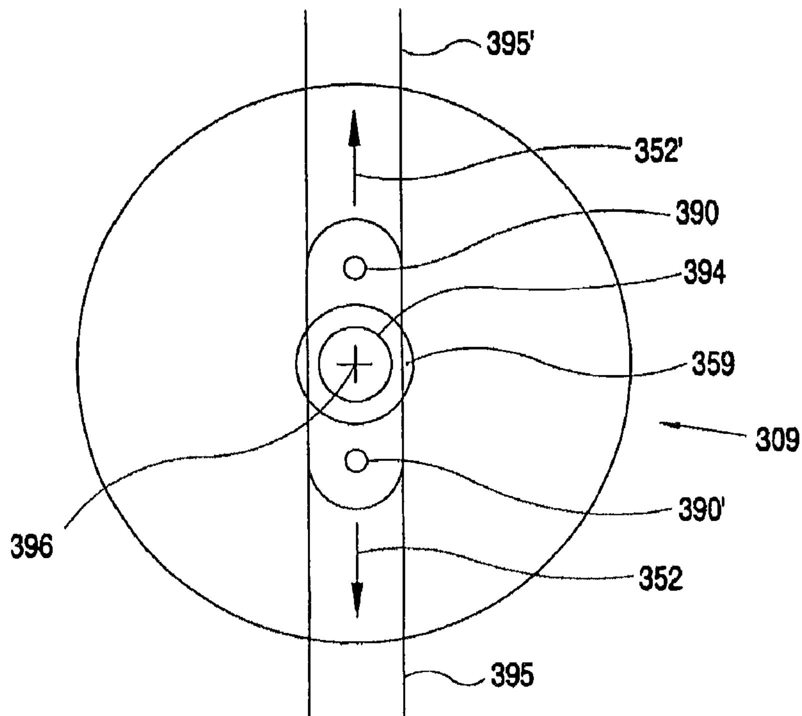

FIG. 8

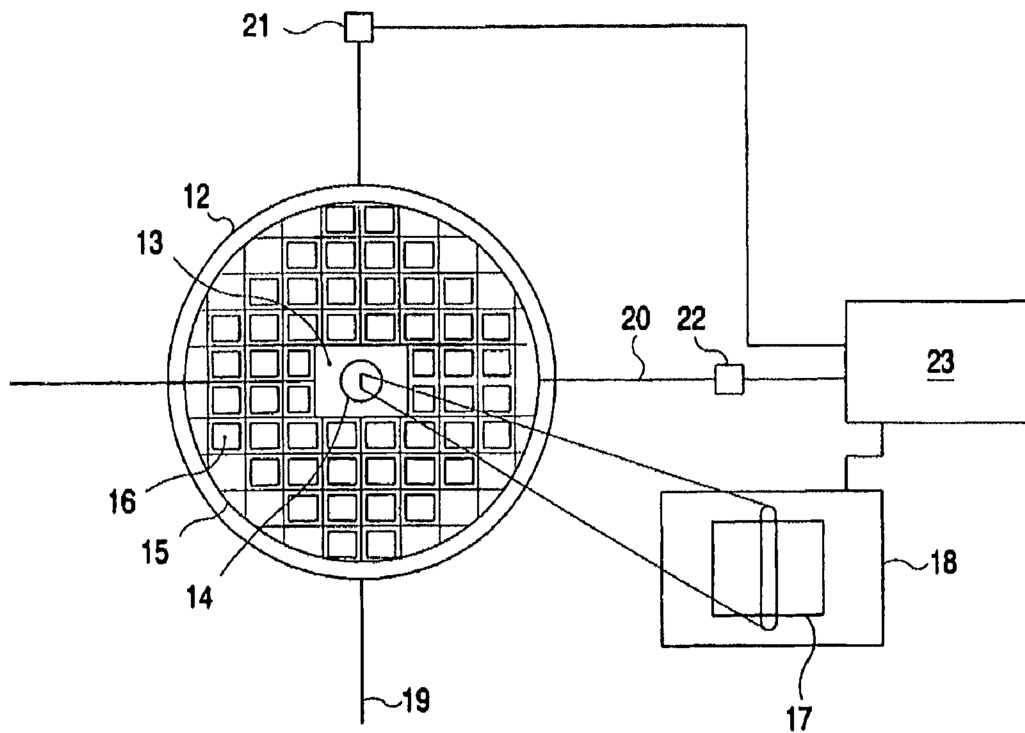

FIG. 9

METHOD AND DEVICE FOR IRRADIATING SPOTS ON A LAYER

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue; a claim printed with strikethrough indicates that the claim was canceled, disclaimed, or held invalid by a prior post-patent action or proceeding.

The present application is a continuation reissue patent application of reissue patent application Ser. No. 13/079,969, filed Apr. 5, 2011 (now U.S. Reissue Pat. No. RE46,433), which is incorporated herein in its entirety by reference, which is a reissue application of U.S. patent application Ser. No. 10/539,313, filed Jun. 15, 2005 (now U.S. Pat. No. 7,514,699), which is national stage application of PCT/IB2003/05344, filed Nov. 20, 2003, and which claims priority to European patent application no. 02080392, filed Dec. 19, 2002.

More than one reissue application has been filed for the reissue of U.S. Pat. No. 7,514,699. The reissue applications are reissue patent application Ser. No. 15/596,843 (the present application), which is a continuation reissue from reissue patent application Ser. No. 13/079,969, and reissue patent application Ser. No. 13/079,969 (now U.S. Reissue Pat. No. RE46,433), which was the original reissue application.

The invention relates to a method of irradiating a layer according to the introductory portion of claim **1** and to a device for irradiating a layer according to the introductory portion of claim **9**.

Such a method and such a device are known from WO-A-02/13194. According to this publication, the described method and device are used for the manufacturing of an optically scannable information carrier. In such a process, first a master mold is manufactured, and then, by means of the master mold or by means of a daughter mold manufactured by means of the master mold, the information carrier is manufactured by means of a replica process. For manufacturing the master mold, a modulated radiation beam which is directed and focussed to a scanning spot on a photosensitive layer carried by a substrate by means of an optical lens system and the substrate and the lens system are moved relatively to each other. An interspace between the photosensitive layer and a nearest surface of a lens system facing the photosensitive layer is maintained filled up with a liquid.

For moving the substrate relative to the lens system a table carrying the substrate can be rotated about an axis of rotation. By means of a displacement device, the lens system can be displaced with a radial directional component with respect to the axis of rotation of the table. A liquid supply means supplies the liquid into the interspace between the photosensitive layer and a nearest optical surface of the lens system.

A problem of this known method and device is that the immersion of the successive portions of the layer to be irradiated is quite easily disrupted, for instance because the liquid is entrained away from the area of the interspace through which the radiation directed to the radiation spot passes when the layer and the lens move too quickly relative to each other. The immersion can also be disrupted due to important changes in the direction of movement of the lens and the layer relative to each other. The stability of the liquid film between the layer to be irradiated and the nearest optical surface of the lens or lenses can be improved by making the distance between the layer to be irradiated and the nearest optical surface of the lens or lenses very small. However, this entails that the device and in particular the lens nearest to the layer to be irradiated can easily be damaged in the event of contact between the lens and the layer moving relative to each other.

Another method and device for directing a radiation beam to a spot on a photosensitive layer are disclosed in JP-A-10255319. In accordance with this method, a photosensitive layer is applied to a disc-shaped substrate made from glass. The table and the substrate are rotated about an axis of rotation extending perpendicularly to the substrate, and the lens system is displaced, at a comparatively low rate, in a radial direction with respect to the axis of rotation, so that the scanning spot of the radiation beam formed on the photosensitive layer follows a spiral-shaped track on the photosensitive layer. The radiation beam—in this known device a laser beam—is modulated such that a series of irradiated and non-irradiated elements is formed on the spiral-shaped track, which series correspond to a desired series of information elements on the information carrier to be manufactured. The photosensitive layer is subsequently developed, so that the irradiated elements are dissolved and a series of depressions are formed in the photosensitive layer. Next, a comparatively thin aluminum layer is sputtered onto the photosensitive layer, which aluminum layer is subsequently provided with a comparatively thick nickel layer by means of an electro deposition process. The nickel layer thus formed is subsequently removed from the substrate and forms the master mold to be manufactured, which is provided, in the manner described above, with a disc-shaped surface having a series of raised portions corresponding to the desired series of information elements on the information carrier to be manufactured. The master mold thus manufactured can suitably be used in the manufacture of the desired information carriers, however, in general, a number of copies, so-called daughter molds are made by means of the master mold in a replica process. These daughter moulds are used to manufacture the desired information carriers by means of a further replica process, generally an injection molding process. In this manner, the required number of master molds, which are comparatively expensive, is limited. Such a method of manufacturing an optically scannable information carrier, such as a CD or DVD, having pit-shaped information elements by means of a master mold or by means of a daughter mold manufactured by means of the master mold is commonly known and customary.

The interspace between the photosensitive layer and the lens of the lens system facing the photosensitive layer is filled with water. For this purpose, the known device is provided with an outflow opening, which is situated near the axis of rotation of the table. The water supplied via the outflow opening is spread, under the influence of centrifugal forces, substantially throughout the surface of the photosensitive layer, so that also the interspace is filled with water. Since water has a considerably larger optical refractive index than air, the provision of water in the interspace leads to a substantial increase of an angle which the rays originating from the radiation beam and the optical axis of the lens system include at the location of the scanning spot. As a result, the size of the spot formed by the radiation beam on the photosensitive layer is reduced considerably, so that a much larger number of irradiated and non-irradiated ele-

ments can be formed on the photosensitive layer, and the information carrier to be manufactured has a higher information density.

Another example of an application in which the gap between a lens and a surface to be irradiated is maintained filled with a liquid are optical imaging methods and apparatus, such as optical projection lithography, in which the spot formed by the radiation projected onto the surface forms an image or a partial image. Such a method and apparatus are described in international patent application W099/49504.

A drawback of these methods and devices is that the liquid film formed in the interspace is not always reliably maintained fully and in homogenous condition during and after relative displacement of the lens and the surface parallel to the surface. As a result, faults develop in the photosensitive layer. In addition, variations in the condition of the liquid film caused by relative movements of the lens and the surface result in varying forces being exerted on the lens system. Since the lens system is suspended with a limited rigidity, the varying forces exerted by the liquid film cause undesirable vibrations of the lens system, which disturb the precision with which the image is projected onto the surface. Furthermore, a comparatively large quantity of liquid must be supplied to keep a liquid volume in place in the portion of the interspace through which the radiation passes. As a result, the known device must be provided with extensive measures to prevent undesirable contact between the liquid and other parts of the device.

It is an object of this invention to reliably maintain the portion of the interspace between the optical surface nearest to the layer to be irradiated and that layer, through which portion the radiation passes, filled with liquid throughout a larger range of relative velocities and directions of relative displacement of the optical element and the layer.

It is another object of the invention to reduce the risk of damage due to unintentional contact between the optical element and the layer to be irradiated.

According to the invention, these objects are achieved by providing a method according to claim **1**. Also according to the invention, a device according to claim **9** is provided for carrying out a method according to claim **1**.

By providing that at least a portion of the liquid fills up a recess of which an internal surface bounds the portion of the interspace through which the radiation irradiates the spot, the interspace through which the radiation irradiates the spot can be maintained filled up with liquid with improved stability. Furthermore, a given stability of the liquid volume between the at least one optical element and the layer, can be achieved while maintaining a larger distance between the nearest optical surface and the layer to be irradiated, so that the risk of unintentional contact between the optical element and the layer is reduced.

That the method and the device are less sensitive to the velocity and direction of displacement of the optical element and the layer relative to each other and variations therein, is not only advantageous in the manufacturing of optical information carriers or molds therefor, but also in other applications, such as optical projection imaging, and more in particular in for instance wafer steppers and wafer scanners for optical projection lithography, for example for the production of semiconductor devices in which the direction of movement of the optical element relative to the layer is varied substantially when the wafer is stepped relative to the optical element to bring the optical element into a new position opposite the wafer for projecting the reticle onto a new spot on the wafer or for unrolling (scanning) the projected image of the reticle (mask) over a next area on the wafer. The spot is then formed either by the area of projection of the reticle onto the wafer or by the moving area of projection of a running, usually slit shaped, window portion of the reticle obtained by or as if scanning along the reticle in accordance with movement of the wafer relative to the optical element.

Particular embodiments of the invention are set forth in the dependent claims.

Other objects, features and effects as well as details of this invention appear from the detailed description of a preferred form of the invention.

FIG. **1** is a schematic side view of an example of a device for directing radiation to a spot on a layer;

FIG. **2** is a schematic, cross-sectional view of a distal end portion of a first example of an optical system for a device as shown in FIG. **1**, of a layer to which the radiation is directed and of a liquid flow maintained in operation;

FIG. **3** is a schematic, bottom view along the line III-III in FIG. **2**

FIG. **4** is a schematic, cross-sectional view of a distal end portion of a second example of an optical system for a device as shown in FIG. **1**, of a layer to which the radiation is directed and of a liquid flow maintained in operation;

FIG. **5** is a schematic, bottom view along the line V-V in FIG. **4**;

FIG. **6** is a schematic, cross-sectional view of a distal end portion of a third example of an optical system for a device as shown in. FIG. **1**, of a layer to which the radiation is directed and of a liquid flow maintained in operation;

FIG. **7** is a schematic, bottom view along the line VII-VII in FIG. **2**;

FIG. **8** is a schematic, bottom view of a distal end portion of a fourth example of a optical system for a device as shown in FIG. **1**; and

FIG. **9** is a schematic top plan view representation of a wafer stepper/scanner for optical lithography.

In the manufacture of an optically scannable information carrier, such as a CD or a DVD, a disc-shaped substrate **3** of glass (see FIG. **1**) carrying a thin photosensitive layer **5** on one of its two sides is irradiated by means of a modulated radiation beam **7**, for instance a DUV laser beam with a wavelength of approximately 260 nm. To irradiate the photosensitive layer **5**, use is made of an example **25** of a device in accordance with the invention, which device is described hereinafter with reference to FIGS. **1**-**3**. The radiation beam **7** is focused to a scanning spot **11** on the photosensitive layer **5** by an optical system, according to the present example a lens system **9** including a plurality of lenses. The lens system **9** includes an objective lens **55**, which is secured in a lens holder **57**. The lens system **9** further includes a most distal lens **59**, which is the one of the optical elements of the lens system **9** that is located nearest to the layer **5** when in operation. An interspace **53** is maintained between the layer **5** that is irradiated and the one of the lenses of the lens system **9** that is located nearest to the layer **5**. The optical elements may also include other items than lenses, such as filters, shields, diffraction gratings or mirrors.

The layer **5** and the lens system **9** are displaced with respect to each other, so that the modulated radiation beam **7** on the photosensitive layer **5** successively irradiates a series of spaced apart irradiated portions of the layer **5** and does not irradiate portions of the layer **5** in-between the irradiated portions. The irradiated photosensitive layer **5** is subsequently developed by means of a developing liquid, which dissolves the irradiated elements **13** and leaves the

non-irradiated elements **15** on the substrate **3**. It is also possible to provide that the irradiated portions are left while the non-irradiated portions are dissolved. In both cases, a series of pits or bumps, which corresponds to the desired series of pit-shaped information elements on the information carrier, are formed in the photosensitive layer **5**. The photosensitive layer **5** is subsequently covered with a comparatively thin layer of for instance nickel by means of a sputtering process. Subsequently, this thin layer is covered with a comparatively thick nickel layer in an electro deposition process. In the nickel layer, which is eventually removed from the substrate **3**, the pattern of pits formed in the photosensitive layer **5** leaves a corresponding pattern that is a negative of the-pattern to be formed in the information carrier to be manufactured, i.e. the master mold comprises a series of raised portions, which correspond to the series of pit-shaped elements formed in the photosensitive layer **5** and to the desired series of pit-shaped information elements on the information carrier. The master mold is thus rendered suitable for use as a mold in an injection-molding machine for injection molding the desired information carriers. Generally, however, a copy of the master mold is used as the mold for injection molding instead of the master mold, which copy of the master mold is commonly referred to as daughter mold, which is manufactured by means of the master mold using a customary replica process which is known per se.

The substrate **3** with the photosensitive layer **5** is placed on a table **27** that is rotatable about an axis of rotation **29**, which extends perpendicularly to the table **27** and the substrate **3**. The table can be driven by means of a first electromotor **31**. The device **25** further comprises a radiation source **33**, which, in the example shown, is a laser source, which is secured in a fixed position to a frame **35** of the device **25**. It is observed that, as an alternative, the radiation may also be obtained from outside the device. Control over the radiation directed to the layer **5** can be achieved in many ways, for instance by controlling the radiation source **33** and/or by controlling a shutter or radiation diverter (not shown) between the radiation source **33** and the layer **5**.

The optical lens system **9** is secured onto a first traveller **37**, which can be displaced radially (parallel to the X-direction in the drawings) relative to the axis of rotation **29**, by means of a first displacement structure **39**. For this purpose, the first displacement structure **39** includes a second electromotor **41** by means of which the first traveller **37** can be displaced over a straight guide **43**, which extends parallel to the X-direction and is fixed relative to the frame **35**.

A mirror **45** in line with an optical axis **49** of the lens system **9** is also secured to the first traveller **37**. In operation, the radiation beam **7** generated by the radiation source **33** follows a radiation beam path **47** extending parallel to the X-direction, and the radiation beam **7** is deflected by the mirror **45** in a direction parallel to the optical axis **49** of the lens system **9**. The lens system **9** can be displaced in the direction of its optical axis **49** by means of a focus actuator **51**, over comparatively small distances with respect to the first traveller **3**, so that the radiation beam **7** can be focused on the photosensitive layer **5**. The table **27** with the substrate **5** is rotated about the axis of rotation **29** at a comparatively high speed by means of the first motor **31**, and the lens system **9** is displaced parallel to the X-direction by means of the second motor **41** at a comparatively low speed, so that the scanning spot **11** where the radiation beam **7** hits the layer follows a spiral-shaped track over the photosensitive layer **5**, leaving a trail of irradiated and non-irradiated elements extending in accordance with this spiral-shaped track.

The device **25** can suitably be used to manufacture master molds having a comparatively high information density, i.e. by means of the device **25**, a comparatively large number of irradiated elements can be provided per unit area of the photosensitive layer **5**. The attainable information density increases as the scanning spot **11** is smaller. The size of the scanning spot **11** is determined by the wavelength of the radiation beam **7** and by the numerical aperture of the lens system **9**, the numerical aperture depending upon the optical refractive index of the medium present between the lens system **9** and the photosensitive layer **5**. The scanning spot **11** is smaller as the refractive index of the medium present between the lens system **9** and the photosensitive layer **5** is larger. Liquids typically have a much larger optical refractive index than air and therefore the portion of the interspace **53** between the lens system **9** and the photosensitive layer **5** through which the beam **7** extends is maintained filled with a liquid—according to this example water. In the present example, water is also particularly suitable because it is transparent to the DUV radiation beam **7** used and it does not attack the photosensitive layer **5**.

As shown in FIG. **1**, the device **25** according to the present example further includes a liquid removal structure **77**, which is provided with a pick-up mouth **79**. The pick-up mouth **79** is secured onto a second traveller **81** of the device **25**, which can be displaced by means of a second displacement structure **83** of the device **25** in a radial direction with respect to the axis of rotation **29**, according to the present example parallel to the X-direction, but another radial direction of displacement may be provided. For driving the displacement of the second traveller **81**, the second displacement device **83** comprises a third electromotor **85** connected to the second traveller **81** for displacing the second traveller over a straight guide **87**, which is attached to the frame **35** and extends in the directions of displacement of the second traveller **81**.

In operation, the pick-up mouth **79** is displaced by means of the third motor **85**. The third motor **85** is controlled so that the lens system **9** and the pick-up mouth **79** are continuously situated at substantially equal distances R from the axis of rotation **29** of the substrate **3**. In this manner, the pick-up mouth **79** is maintained in a position downstream from the lens system **9** where irradiated portions of the layer **5** pass, so that the liquid supplied at the location of the lens system **9** is entrained by the rotating layer **5** to the pick-up mouth **79** where the liquid is subsequently picked-up from the photosensitive layer **5** by the pick-up mouth **79**. As the water is thus removed from the photosensitive layer **5** downstream from the lens system **9**, it is substantially precluded that water that has already been used finds its way back to the interspace **53**, thereby disturbing the accurately dosed liquid flow in the interspace **53**. In operation, the pick-up mouth **79** is always at a distance R from the axis of rotation **29** which corresponds to the distance R at which the lens system **9** is situated from the axis of rotation **29**, both the size and the capacity of the pick-up mouth **79** need only to be comparatively small to remove liquid that has already been used.

FIGS. **2** and **3** show, in more detail, the lens system **9**, the substrate **3** with the photosensitive layer **5**, and the interspace **53** between the-photosensitive layer **5** and the lens system **9**. The lens **59** nearest to the layer **5** has an optical surface **63** facing the substrate **3**. The lenses **55**, **59** are suspended in a housing **61**, which includes a flat wall **65**, which faces the layer **5** and which substantially extends in an

imaginary plane perpendicular to the optical axis of the lens **59** nearest to the layer **5**. Between the lens **59** nearest to the layer **5** and the layer **5**, a passage **90** is provided in the wall **65**, which faces the layer **5**. The *wall 65 containing the* passage **90** and the surface **63** of the lens **59** nearest to the layer **5** form a recess **92**, *inclusive of the passage 90,* in the surface of the wall **65** facing the spot **11** to which the radiation **7** is directed. The surface **63** of the lens **59** nearest to the layer **5** is part of the internal surface of the recess **92** and bounds the portion of the interspace **53** through which the radiation **7** irradiates the spot **11**. According to the present example, the surface **63** of the lens **59** nearest to the layer **5** is flat, however, this surface may also be concave or convex.

In the carrier **61**, a liquid supply **67** has a port **69** that opens into the recess **92** directly adjacent the lens **59** nearest to the layer **5**. In operation, the portion of the interspace **53** through which the radiation **7** irradiates the spot **11** on the layer **5** is maintained filled with liquid **91**. To this end, the liquid **91** is supplied via the port **69** into a portion of the interspace **53** in the recess **92** and through which the radiation **7** irradiates the spot **11**. Via a most downstream outflow opening, formed by the passage **90** in the wall **65** between the spot **11** and the surface **63** of the lens **59**, the liquid **91** is subsequently also fed to and fills up a portion of the interspace **53** between the wall **65** and the layer **5**. In the recess **92**, the liquid **91** is, at least to an important extent, protected against being entrained from the interspace **53**. Since, the liquid **91** is less susceptible to being entrained away from the portion of the interspace **53** through which the radiation passes to the spot **11**, occurrence of the associated optical distortion caused by the portion of the interspace **53** through which the radiation passes not being completely filled with liquid is thus counteracted.

Moreover, the size of the interspace **53** measured parallel to the optical axis of the lenses **55**, **59**—and thus the distance between the lens **59** and the layer **5**—can be relatively large without causing the liquid to be entrained along with movement of the layer **5** too easily. In turn, this reduces the risk of damage to the lens **59** nearest to the layer **5**. Moreover, the allowable tolerances on the tilt of the lens can be larger without increasing the risk of the lens **59** touching the layer **5**.

The recess **92** may be positioned and of such dimensions, so that only a portion of the radiation passes through the recess. However, for a particularly effective protection of liquid **91** across the whole radiation beam, it is preferred that the recess **92** has a rim portion **93** closest to the layer **5**, which extends around the radiation **7** irradiating the spot **11**. Accordingly, the portion of the interspace **53** in the recess **92** in which liquid **91** is shielded from being entrained extends throughout the whole cross-section of the radiation beam **7**.

According to the present example, the recess **92** is bounded by **[**the passage **90** in**]** the wall **65** *containing the passage 90* between the spot **11** and the lens **59** nearest to the spot **11**, and by the surface **63** of the lens **59**. The surface **63** of the lens **59** nearest to the spot **11** is thereby shield by the wall **65**, so that the risk of damage to the lens **59** is virtually eliminated. Moreover, since the wall **65** also shields the liquid **91**, the nearest lens **59** does not need to be positioned very near to the layer **5** to effectively keep the interspace **53** between the layer **5** and the nearest lens **59** filled with liquid. The distance between the wall **65** and the layer **5** can be selected to be quite small so that a very effective capillary effect can be achieved for keeping a liquid film in place in the portion of the interspace **53** in the periphery of the passage **90**, because inadvertent contact between the wall **65** and the layer **5** has far less detrimental effects than contact between an optical surface such as a lens surface and the layer **5**. The wall **65** is preferably made of or covered with a relatively soft material, such as plastic material, so that there is little risk of damage in the event of inadvertent contact between the wall **65** and the layer **5**.

The optimum working distance between the layer **5** and the wall **65**, i.e. the portion of the lens assembly nearest to the layer **5**, is determined by two factors. On the one hand, the distance should be large enough to retain sufficient tolerance on the distance between the substrate **3** and arrangement of the lenses **55**, **59** and the housing **61**. On the other hand, this distance should not be too large because this would require a too large liquid flow to maintain the immersed condition of the portion of the interspace **53** through which the radiation passes to the spot **11**. A presently preferred range for the smallest thickness of the interspace **53** is 3-1500 μm and more preferably 3-500 μm if the liquid is water, larger values for the smallest thickness of the interspace can be particularly advantageous if the liquid has a larger viscosity than water. Also the width of the outflow opening affects the upper end of the preferred range for the smallest thickness of the interspace, the smallest thickness of the interspace being preferably smaller than (100+½*W) μm in which W is the overall width of the outflow opening measured in a plane parallel to the layer **5**.

Due to the presence of a recess facing the layer **5**, the distance between the layer **5** and the nearest optical surface may be larger than approximately 10 μm, for instance larger than 15 m, 30 μm or even 100 μm, to increase the insensitivity to tolerances and to further reduce the risk of contact between the layer and an optical surface.

In the device **25** according to the present example, the liquid supply structure **67** communicates with the passage **90** for maintaining a liquid outflow via the passage **90**.

Since the liquid **91** flows out towards the layer **5** via the passage **90** in the wall **65** between the lens **59** and the layer S through which also the radiation **7** passes to the spot **11**, the liquid **91** is particularly effectively guided through the interspace **53** through which the radiation passes to the spot **11**. Moreover, since the radiation **7** passes to the spot **11** through the outflow opening **90** through which the liquid **91** is directed, the radiation beam **7** extends through the area through which the liquid **91** flows out. This results in a very reliable full immersion of the portion of the interspace **53** through which the radiation passes to the spot during movement parallel to the layer **5** of the lens **59** and the layer **5** relative to each other. Yet another advantage of causing the liquid to flow out via an opening through which also the radiation for irradiating the spot is passed is that a relatively high pressure can be maintained in the immersed area through which the radiation passes. This in turn reduces the risk of bubble formation, which may for instance be caused by gasses dissolved in the liquid under influence of an increase of temperature.

To avoid inclusion of air bubbles in the liquid and for reliably maintaining the filled condition of the portion of the interspace **53** through which the radiation **7** passes to the spot **11**, liquid outflow via the outflow opening **90** is preferably such that a liquid volume between the wall **65** and the layer **5** is maintained which includes a liquid volume upstream of the portion of the interspace **53** through which the radiation irradiates the spot **11**. Thus, a safety margin of liquid upstream (in a direction opposite to the direction of relative movement of the layer **5** in the area of the spot **11**) is formed which ensures that, variations in the distance over which liquid is urged in upstream direction do not cause a

disruption of the completely filled condition of the portion of the interspace **53** intersected by the radiation **7** passing to the spot **11**.

Furthermore, the liquid **91** flows out from the most downstream outflow opening **90** over a cross-section larger than the largest cross section **94** of the portion of the interspace **53** through which the radiation irradiates the spot **11**. This also contributes to the reliable immersion of the interspace **53** with the liquid **91**.

As can be seen in FIGS. **2** and **3**, the outflow opening **90** has a total projected cross-sectional passage area in a plane parallel to the layer **5** of which, seen in a direction parallel to the optical axis of the lens system **109**, the centre is located inside the portion of the interspace **53** through which the radiation **7** irradiates the spot. **11**. Accordingly, the average path along which liquid flows out is at least to a large extent centred relative to the portion of the interspace **53** through which radiation passes to the spot **11**. Accordingly, the direction of movement of the layer **5** and the lens arrangement **9** relative to each other in the area of the spot **11** can be varied substantially without disrupting complete immersion of the portion of the interspace **53** through which the spot **11** is irradiated. Even if the direction of movement of the layer **5** is varied substantially, the trace of liquid **95** will still cover the entire portion of the interspace **53** through which the spot is irradiated. Nevertheless, areas of the outflow opening **90** around the beam **7** are located close to the beam, so that superfluous wetting of the layer **5** is limited.

According to the present example, the portion of the interspace **53** through which the radiation **7** irradiates the spot **11** is also centrally located relative to the outflow opening **90** to such an extent that the trace **95** of liquid **91** fed from the outflow opening **90** into the interspace **53** completely immerses the portion of the interspace **53** through which the radiation **7** irradiates the spot **11**, not only while, in the position of the spot **11**, the layer **5** and the at least one lens system **9** move relative to each other in the direction indicated by the arrow **52** (which indicates the direction of movement of the layer **5** relative to the lens system **9**), but also while, in the position of the spot **11**, the layer **5** and lens system **9** move relative to each other in opposite direction.

More specifically, because in the example shown in FIGS. **2** and **3** the radiation beam **7** passes centrally through the cross-sectional area of the outflow opening **90**, the liquid **91** flowing into and out of the outflow opening **90** already immerses the portion of the interspace **53** through which the radiation **7** irradiates the spot **11**.

The more the direction of movement of the layer **5** and the lens system **9** parallel to the layer **5** in the area of the spot **11** can be changed without disrupting the immersion of the portion **94** of the area **53** through which the radiation passes, the more the device is suitable for applications in which the spot **11** needs to move over the surface of the layer in widely varying directions, such as in imaging processes in which the spot is a two-dimensional image projected to the layer **5**. In such applications, the advantage of a comparatively large refractive index between the lens system and the medium between the lens system and the irradiated surface is that the image can be projected with a higher resolution, which in turn allows further miniaturization and/or an improved reliability.

An example of such applications is optical projection lithography for the processing of wafers for the manufacture of semiconductor devices. An apparatus and a method for this purpose are schematically illustrated in FIG. **9**. Wafer steppers and wafer scanners are commercially available. Accordingly, such methods and apparatus are not described in great detail, but primarily to provide an understanding of liquid immersion as proposed in the present application in the context of such optical imaging applications.

The projection lithography apparatus according to FIG. **9** includes a wafer support **12** and a projector **13** having a lens assembly **14** above the wafer support **12**. In FIG. **9**, the wafer support **12** carries a wafer **15** on which a plurality of areas **16** are intended to be irradiated by a beam projecting an image or partial image of a mask or reticle **17** in a scanner **18** operatively connected to the projector **13**. The support table is moveable in X and Y direction along spindles **19**, **20** driven by spindle drives **21**, **22**. The spindle drives **21**, **22** and the scanner **18** are connected to a control unit **23**.

Usually one of two principles of operation are applied in optical lithography. In the so-called wafer stepper mode, the projector projects a complete image of the reticle onto one of the areas **16** on the wafer **15**. When the required exposure time has been reached, the light beam is switched off or obscured and the wafer **15** is moved by the spindle drives **21**, **22** until a next area **16** of the wafer is in the required position in front of the lens assembly **14**. Dependent on the relative positions of the exposed area and the next area to be exposed, this may involve relatively quick movement of the lens assembly **14** along the surface of the wafer in widely varying directions. The size of the irradiated spot on the surface of the wafer in which the image of the reticle is projected is typically about 20×20 mm, but larger and smaller spots are conceivable.

In particular when it is desired to manufacture larger semiconductor units, it is advantageous to project the image in the other mode, generally referred to as the wafer scanner mode. In that mode, only a slit-shaped portion of the reticle is projected as a slit shaped spot having a length that is several (for instance four or more times) times larger than its width in an area **16** of the surface of the wafer **15**. A typical size for the spot is for instance about 30×5 mm). Then, the reticle **17** to be scanned is moved along scanning window while the wafer support **12** is synchronously moved relative to the lens assembly **14** under control of the control unit **23** with a velocity adapted so that only the projection spot, but not the scanned partial image portions of the reticle **17** that are projected on the wafer move relative to the wafer **15**. Thus, the image of the reticle **17** is transferred to an area **16** of the wafer. The movement of the wafer **15** relative to the lens assembly **14** while a running window portion of the reticle is projected onto the wafer **15** is usually carried out slowly and usually each time in the same direction. After the complete image of a reticle **17** has been projected onto the wafer **15**, the wafer **15** is generally moved much more quickly relative to the lens assembly **14** to bring a next area of the wafer **15** where a next image of the or a reticle **17** is to be projected in front of the lens assembly **14**. This movement is carried out in widely varying directions dependent on the relative positions of the exposed area **16** of the wafer **15** and the next area **16** of the wafer **15** to be exposed. To be able to recommence radiating the surface of the wafer **15** after the displacement of the wafer **15** relative to the lens **14** (i.e. also the lens or the lens and the wafer may be moved), it is advantageous if the liquid volume in the interspace between the lens **14** and the surface of the wafer **15** through which the radiation passes is immediately filled with liquid after completion of that movement, so that the space is reliably immersed before irradiation is recommenced.

Also for optical lithography, water can be used, for instance if the radiation is light of a wavelength of 193 nm. However in some circumstances other liquids may be more suitable.

FIGS. **4** and **5** show a distal end portion of a second example **109** of a lens system for devices such as the devices shown in FIGS. **1** and **9**. The lens system **109** according to this example includes a housing **161**, a lens **159** nearest to the layer **5** on the substrate **3**. According to this example, the recess **192** is bound by a concave portion of the surface **163** of the lens **159** nearest to the spot **11** on the layer **5** to which the beam of radiation **107** is directed. This allows to obtain the liquid retaining characteristics of a recess in combination with a relatively uniform flow pattern throughout the portion **194** of the interspace **153** through which radiation **107** passes to the spot **11**. In particular, a uniform pattern of flow velocity gradients in the interspace **153** is obtained. In turn, the relatively uniform flow pattern is advantageous to avoid inducing vibrations and for obtaining a continuous uniform supply of fresh liquid and thereby a uniform, steady liquid temperature. These effects are both advantageous for avoiding optical disturbance of the radiation beam **107**.

In FIG. **5**, the dotted circle designated by reference numeral **194** indicates the largest cross section of the portion of the interspace **153** between the lens **159** and the layer **5** through which the radiation beam **107** passes.

For supplying liquid **191** to the interspace **153** between the lens **159** and the layer **5**, a liquid supply conduit **167** extends through the housing **161** and leads to an outflow opening **190**. According to the present example, the outflow opening **190** has the form of a canal structure in a surface **154** facing the layer **5**. The canal structure **190** is open towards the layer **5**, for distributing supplied liquid **191** longitudinally along the canal **190** and dispensing distributed liquid towards the layer **5**. In operation, the liquid **191** is distributed by the canal structure **190** longitudinally along that canal structure and liquid **191** is dispensed from the canal structure **190** towards the layer **5**. This results in a relatively wide, flat liquid trace **195** and full immersion of the portion **194** of the interspace **153** through which the radiation beam **107** passes, even if the direction of movement of the lens system **109** and the layer **5** relative to each other parallel to the plane of the layer **5** is changed substantially.

The canal **190** can have various forms. In the embodiment shown in FIGS, **4** and **5**, the canal is formed such that the outflow opening **190** is located outside the radiation beam **107** and extends around the portion **194** of the interspace **153** through which the radiation **7** irradiates the spot **11**. The cross **196** indicates the centre, seen in a direction parallel to the optical axis of the lens system **109**, of the total cross-sectional passage area of the outflow opening **190**. Also in this embodiment, seen in a direction parallel to the optical axis of the lens system **109**, the centre of the total cross-sectional passage area of the outflow opening **190** is located inside the portion **194** of the interspace **153** through which the radiation **107** irradiates the spot **11**. Furthermore, as in the embodiment discussed above, the portion **194** of the interspace **153** through which the radiation **107** irradiates the spot **11** is centrally located relative to the cross-sectional area of the outflow opening **190** to such an extent that the direction of movement of the lens system **9** and the layer **5**, relative to each other and parallel to the plane of the layer **5**, can be reversed without disrupting the full immersion of the portion **194** of the interspace **153** through which the radiation beam **107** passes.

Another feature the outflow opening **190** of the example shown in FIGS. **4** and **5** has in common with the outflow opening **90** shown in FIGS, **2** and **3** is that, seen in a direction parallel to the optical axis of the lens system **109**, it includes portions that are spaced about the portion **194** of the interspace **153** through which the radiation beam **107** irradiates the spot **11**, over such an angle that the trace of liquid **195** fed from the outflow opening **190** into the interspace **153** completely immerses the portion **194** of the interspace through which the radiation irradiates the spot **11** while, in the position of the spot **11**, the layer **5** and the lens system **109** move relative to each other in directions parallel to the layer **5** that may be perpendicular to each other. The ability to keep the portion **194** of the interspace through which the radiation passes immersed during movements of the layer **5** and the lens system **109** relative to each other in directions perpendicular to each other is of particular advantage, because it allows to write an image onto the layer **5** while making movements in X- and Y-directions.

The liquid **191** is preferably supplied at a pressure drop over the liquid between the canal structure **190** and the environment that is just sufficient to keep portion of the interspace **153** through which the radiation passes reliably immersed. Thus, the amount of water fed to the surface is kept to a minimum.

Furthermore, when the liquid **191** is dispensed via a canal shaped outflow opening **190**, the smallest thickness of the interspace **153** (in this example the distance between the layer **5** and the surface **154** of the wall portion **165**) may be larger, without causing an undue risk of disrupting the immersion of the portion **194** of the interspace through which the radiation passes.

The flow rate with which the liquid **191** is supplied is preferably as follows: if the interspace **153** between layer **5** and the surface of the lens system **109** nearest to the layer **5** has a smallest thickness H (measured perpendicular to the layer **5**), the layer **5** and the at least one lens **159** are moved relative to each other at a velocity V, the liquid **191** is supplied via an outflow opening **190** having a diameter D measured in a plane parallel to the layer **5**, the flow rate is preferably equal to $0.5*\beta*H*(D+\alpha*H)*V$, where α is a constant between 1 and 10 and β is a constant between 1 and 3.

Thus, it can be reliably ensured that a laminar flow with an essentially linear velocity profile and preferably a homogeneous Couette flow is present in the interspace **153**. Such a flow exerts a substantially constant force on the wall **165** in which the canal **190** is provided and on the side **163** of the lens **159** nearest to the layer **5**. As a result, the water present in the interspace **153** exerts substantially no variable liquid forces on the lens system **109**. Such varying liquid forces would lead to undesirable vibrations of the lens system **109** and hence to focusing errors and positioning errors of the radiation beam **107** on the photosensitive layer **5**. The flow is preferably free of air inclusions, so that the radiation beam **107** is not disturbed thereby.

In FIGS. **6** and **7**, a third example of a lens system **209** for devices such as the devices shown in FIGS. **1** and **9** is shown. According to this example, the outflow opening **290** downstream of the liquid supply canal **267** is also provided with a canal structure open towards the layer **5** (i.e. in the direction in which the beam **207** is directed), but has a different, rectangular shape when seen in axial direction of the lens system **209**. An essentially rectangular shape is particularly advantageous for reliably immersing a rectangular area **294** of the interspace intersected by the radiation beam while maintaining a uniform liquid flow patter

throughout the intersected portion **294** of the interspace, in particular if the movement of the lens system **209** and the layer **5** relative to each other is in a direction perpendicular to one of the sides of the rectangular canal structure **290**. Such circumstances typically occur in optical projection lithography.

As in the example shown in FIGS. **2** and **3**, the recess **292** is bounded by a passage **295** in a wall **265** perpendicular to the axis of the lens system **9** and a surface of the lens **259** nearest to the spot **11** and the surface of the lens **259** nearest to the spot **11** also bounds the portion **294** of the interspace **253** through which the radiation **207** passes to the spot **1**. Accordingly, the lens **259** is effectively protected against damage due to inadvertent contact between the lens system **209** and the layer **5** on the substrate **3**. However, according to this example, the passage **295** is not an outflow opening via which liquid is dispensed.

The lens system **309** shown in FIG. **8** is provided with two most downstream outflow openings **390**, **390'** and the portion **394** of the interspace through which the radiation passes to the spot on the layer to be irradiated is located centrally relative to the outflow openings, so that the portion **394** of the interspace through which the radiation passes is fully immersed in a liquid trace **395** dispensed from a first one of the outflow openings **390** if the movement of the layer relative to the lens system **309** in the area of the spot is in a first direction indicated with an arrow **352** and fully immersed in liquid trace **395'** dispensed from the other one of the outflow openings **390'** if the movement of the layer relative to the lens system **309** in the area of the spot is in a second, opposite direction indicated with an arrow **352'**. If it is desired to ensure immersion during relative movement of the lens system **309** and the layer in other directions parallel to the layer, outflow openings **390** can be provided in other angular positions relative to the portion **394** of the interspace through which the radiation is passed, the pressure drop and the flow rate can be increased to create wider liquid traces and/or the outflow openings can be of a different design, for instance slit shaped wherein the slit may for instance be straight or curved about the optical axis of the lens system **309**.

Also in the lens system **309** according to this example, seen in a direction parallel to the optical axis of the lens system **309**, the centre **396** of the total cross-sectional passage area of the outflow openings **390**, **390'** is located inside the portion **394** of the interspace **353** through which the radiation passes to the spot **11**.

A particular advantage of having a plurality of outflow openings circumferentially spaced around the portion **394** of the interspace through which the radiation passes to the spot on the layer to be irradiated is, that dependent of the direction of movement of the layer and the lens system **309** relative to each other, liquid can be fed selectively from the outflow opening or openings upstream of the spot on the layer to be irradiated only. Thus, the flow rate of the liquid can be limited and the amount of liquid that needs to be picked up is reduced.

The invention claimed is:

[1. A method of irradiating a layer including:

directing and focussing a radiation beam to a spot on said layer by means of at least one optical element;

causing relative movement of the layer relative to said at least one optical element so that, successively, different portions of the layer are irradiated and an interspace between a surface of said at least one optical element nearest to said layer is maintained; and

maintaining said interspace through which said radiation irradiates said spot on said layer filled with a liquid, the liquid being supplied via a supply conduit;

characterized in that at least a portion of said interspace is bounded by a recess which is filled by at least a portion of said liquid, said radiation beam passing through said liquid in said recess when irradiating said spot, wherein said recess is bounded by a passage in a wall between said layer and a surface of said at least one optical element nearest to said layer and by said at least one optical element nearest to said layer, said radiation beam passing through said passage.**]**

[2. The method as claimed in claim **1**, wherein the recess has a rim portion positioned between said surface of said at least one optical element nearest to said layer and said layer, closest to said layer and extending around said radiation beam irradiating said spot.**]**

[3. The method as claimed in claim **1**, wherein a liquid outflow from said recess via said passage is maintained.**]**

[4. A The method as claimed in claim **1**, wherein a smallest thickness of said interspace is maintained of 3-1500 μm.**]**

[5. A The method as claimed in claim **1**, wherein said recess includes a concave portion of said surface of said at least one optical element nearest to said layer.**]**

[6. A The method as claimed in claim **1**, wherein the liquid flows out from at least one outflow opening in said recess in the form of at least one canal open towards said layer, said canal distributing supplied liquid longitudinally along said canal and dispensing distributed liquid towards said layer.**]**

[7. A method of irradiating a layer including:

directing and focusing a radiation beam to spot on said layer by means of at least one optical element;

causing relative movement of the layer relative to said at least one optical element so that, successively, different portions of the layer are irradiated and an interspace between a surface of said at least one optical element nearest to said layer is maintained; and

maintaining at least a portion of said interspace through which said radiation irradiates said spot on said layer filled with a liquid, the liquid being supplied via a supply conduit;

characterized in that at least a portion of said liquid fills up a recess through which said radiation irradiates said spot,

wherein said interspace between said layer and said surface of said at least one optical element nearest to said layer has a thickness H, the layer and the at least one optical element are moved relative to each other at a velocity V, the liquid is supplied via an outflow opening having a width W measured in a plane parallel to said layer and at a flow rate equal to 0.5*•*H*(W+•*H)*V, where • is a constant between 1 and 10 and • is a constant between 1 and 3.**]**

[8. A device for directing radiation to a layer including:

at least one optical element for focussing radiation originating from said radiation source to a spot on said layer;

a displacement structure for causing relative movement of the layer relative to said at least one optical element so that, successively, different portions of the layer are irradiated and an interspace between said layer and a surface of said at least one optical element nearest to said spot is maintained; and

an outflow opening for supplying liquid to fill said interspace, in operation, said radiation irradiates said spot on said layer through said liquid,

characterized in that said device further comprises a recess having an internal surface bounding at least said

portion of said interspace through which said radiation irradiates said spot, said outflow opening being formed in said recess, wherein said recess is bounded by a passage in a wall between said spot and a surface of said at least one optical element nearest to said spot and by said surface of said at least one optical element nearest to said spot, said passage forming said outflow opening.]

[**9**. The device as claimed in claim **8**, wherein said recess has a rim portion closest to said layer extending around said portion of said interspace through which, in operation, said radiation irradiates said spot.]

[**10**. The device as claimed in claim **8**, wherein said device further comprises a liquid supply structure communicating with said recess for maintaining a liquid outflow via said passage.]

[**11**. The device as claimed in claim **8**, wherein said device is arranged for maintaining a smallest thickness of said interspace of 3-1500 μm.]

[**12**. The device as claimed in claim **8**, wherein said recess includes a concave portion of said surface of said at least one optical element nearest to said spot.]

[**13**. The device claimed in claim **8**, wherein the at least one outflow opening is formed by at least one canal open towards said layer, for distributing supplied liquid longitudinally along said canal and dispensing distributed liquid towards said layer.]

14. A structure for a lithography apparatus comprising a movable wafer support table configured to support a wafer, and an optical element, nearest to the wafer support table, configured to pass a radiation beam from a reticle or mask to the wafer, the structure configured for being located adjacent the optical element, configured to receive a liquid and configured to maintain an interspace between a bottom surface of the optical element and the wafer support table and through which the radiation beam irradiates the wafer, filled with the liquid, the structure comprising:

- *an internal surface to bound at least a portion of the interspace between the bottom surface of the optical element and the wafer support table,*
- *a wall configured to be between the wafer and the surface of the optical element, wherein the interspace is bounded at least in part by the wall and by the surface of the optical element, wherein the wall is arranged to extend essentially perpendicularly to an optical axis, through the interspace, of the radiation beam and has its width in a horizontal direction larger than its height in a vertical direction,*
- *a passage formed in the wall, the passage arranged to allow the radiation beam and liquid to pass therethrough out onto the wafer, and*
- *a port configured to fill the interspace with the liquid, wherein the port is located inside the structure.*

15. The structure of claim 14, wherein the wall is configured to extend at least partly underneath the surface of the optical element.

16. The structure of claim 14, further comprising a channel configured to be located at least partly below the surface of the optical element, the channel configured to direct a flow of the liquid in a direction essentially perpendicular to the optical axis.

17. The structure of claim 16, wherein parts of the channel are arranged to be located on opposite sides of the optical axis.

18. The structure of claim 14, wherein a cross-sectional dimension of the passage is arranged to be smaller than a cross-sectional dimension of the optical element.

19. The structure of claim 14, wherein the wall is arranged to intersect at an angle a further wall at a location below the surface of the optical element.

20. The structure of claim 14, wherein the structure has its width in a horizontal direction larger than its height in a vertical direction.

21. A structure for a lithography apparatus comprising a movable wafer support table configured to support a wafer, and an optical element, nearest to the wafer support table, configured to pass a radiation beam from a reticle or mask to the wafer, the structure configured for being located adjacent the optical element, configured to receive a liquid and configured to maintain an interspace between a bottom surface of the optical element and the wafer support table and through which the radiation beam irradiates the wafer, filled with the liquid, the structure comprising:

- *an internal surface bounding at least a portion of the interspace between the bottom surface of the optical element and the wafer support table,*
- *a wall between the wafer and the surface of the optical element, wherein the interspace is bounded at least in part by the wall and by the surface of the optical element, wherein the wall comprises an essentially plane parallel plate arranged to extend essentially perpendicularly to an optical axis, through the interspace, of the radiation beam,*
- *a passage formed in the wall, the passage arranged to allow the radiation beam and liquid to pass therethrough out onto the wafer, and*
- *a port configured to fill the interspace with the liquid, wherein the port is located inside the structure.*

22. The structure of claim 21, wherein the wall is configured to extend at least partly underneath the surface of the optical element.

23. The structure of claim 21, further comprising a channel configured to be located at least partly below the surface of the optical element, the channel configured to direct a flow of the liquid in a direction essentially perpendicular to the optical axis.

24. The structure of claim 21, wherein a cross-sectional dimension of the passage is arranged to be smaller than a cross-sectional dimension of the optical element.

25. The structure of claim 21, wherein the wall has its width in a horizontal direction larger than its height in a vertical direction.

26. The structure of claim 21, wherein the wall is arranged to intersect at an angle a further wall at a location below the surface of the optical element.

27. The structure of claim 21, wherein the structure has its width in a horizontal direction larger than its height in a vertical direction.

28. A structure for a lithography apparatus comprising a movable wafer support table configured to support a wafer, and an optical element, nearest to the wafer support table, configured to pass a radiation beam from a reticle or mask to the wafer, the structure configured for being located adjacent the optical element, configured to receive a liquid and configured to maintain an interspace between a surface of the optical element and the wafer support table and through which the radiation beam irradiates the wafer, filled with the liquid, the structure comprising:

- *an internal surface to bound at least a portion of the interspace between the surface of the optical element and the wafer support table,*
- *a wall configured to be between the wafer and the surface of the optical element, wherein the interspace is bounded at least in part by the wall and by the surface*

of the optical element, wherein the wall is arranged to have a surface nearest the wafer when supported by the wafer support table that is essentially perpendicular to an optical axis, through the interspace, of the radiation beam,

a passage formed in the wall, the passage arranged to allow the radiation beam and liquid to pass therethrough out onto the wafer, and

a port configured to fill the interspace with the liquid, wherein the port is located inside the structure.

29. The structure of claim 28, wherein the wall is configured to extend at least partly underneath the surface of the optical element.

30. The structure of claim 28, further comprising a channel configured to be located at least partly below the surface of the optical element, the channel configured to direct a flow of the liquid in a direction essentially perpendicular to the optical axis.

31. The structure of claim 28, wherein a cross-sectional dimension of the passage is arranged to be smaller than a cross-sectional dimension of the optical element.

32. The structure of claim 28, wherein the wall has its width in a horizontal direction larger than its height in a vertical direction.

33. The structure of claim 28, wherein the structure has its width in a horizontal direction larger than its height in a vertical direction.

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