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(54) **Title**: SPECTRAL FILTER FOR SPLITTING A BEAM WITH ELECTROMAGNETIC RADIATION HAVING WAVELENGTHS IN THE EXTREME ULTRAVIOLET (EUV) OR SOFT X-RAY (SOFT X) AND THE INFRARED (IR) WAVELENGTH RANGE

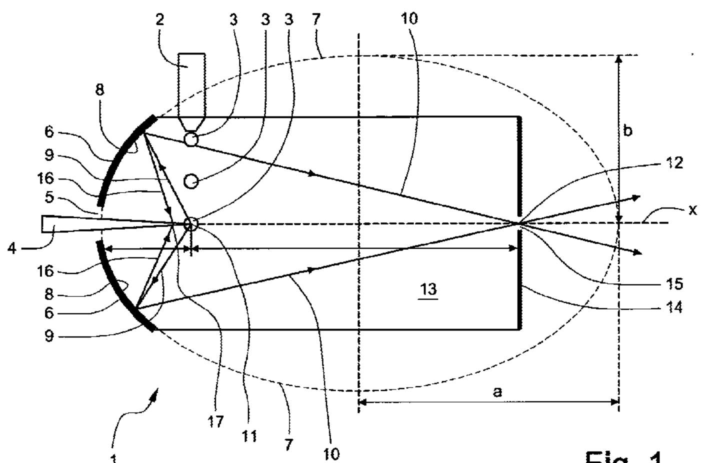

Fig. 1

(57) **Abstract**: Spectral filter for splitting the primary radiation from a generated beam with primary electromagnetic radiation having a wavelength in the extreme ultraviolet (EUV radiation) or soft X-ray (soft X) wavelength range and parasitic radiation having a wavelength in the infrared wavelength range (IR radiation) in an optical device, comprising a surface for reflecting electromagnetic radiation with a wavelength in the extreme ultraviolet wavelength range {EUV radiation), the surface being formed by an EUV radiation-reflecting multilayer structure, which multilayer structure has a pattern of at least one system of concentric grooves mutually separated by concentric rings, wherein the width and depth of the grooves and the width of the rings are selected such that the concentric grooves and rings form Fresnel zones for reflecting radiation with a wavelength in the infrared wavelength range (IR radiation) incident on these grooves and rings, and method for the manufacture thereof.

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SPECTRAL FILTER FOR SPLITTING A BEAM WITH ELECTROMAGNETIC RADIATION HAVING WAVELENGTHS IN THE EXTREME ULTRAVIOLET (EUV) OR SOFT X-RAY (SOFT X) AND THE INFRARED (IR) WAVELENGTH RANGE

The invention relates to a spectral filter for splitting the primary radiation from a generated beam with primary electromagnetic radiation having a wavelength in the extreme ultraviolet (EUV radiation) or soft X-ray (soft X) wavelength range and parasitic radiation having a wavelength in the infrared wavelength range (IR radiation) in an optical device, comprising a surface for reflecting electromagnetic radiation with a wavelength in the extreme ultraviolet wavelength range (EUV radiation), the surface being formed by an EUV radiation-reflecting multilayer structure.

This spectral filter is particularly intended for application in a device for EUV lithography. The source for the necessary EUV radiation in such a device is for instance a plasma which is excited with a beam of infrared (IR) light, with a wavelength of 10.6 μm, coming from a CO_2 laser. During the excitation of a plasma using IR light about 5% of the power incident on a target which generates the plasma is converted into EUV radiation, a part of the non-converted IR light is absorbed in predetermined manner and a part is reflected by the plasma as parasitic radiation in the direction of the optical components which collimate the generated EUV radiation. The resulting presence of parasitic IR radiation in the primary beam of EUV radiation has undesirable effects, such as the heating of optical components or a photoresist layer to be exposed in the lithography device.

Known from WO 02/12928 A2 is a diffractive spectral filter in an optical condenser in a device for lithography with extreme ultraviolet radiation. The spectral filter is applied for the purpose of eliminating visible light and ultraviolet light from a generated beam of EUV radiation and comprises a reflective optical grating of the blazed grating type, which in a cross-section has a sawtooth profile which extends over a main plane with a determined periodicity (the line distance (a) of the grating), wherein the long sides of the sawtooth profile enclose a determined acute angle (the blaze angle (γ)) with the main plane. The optical grating has a spatial frequency of the lines of the grating of about 150 to 2000 mm^{-1}, this corresponding to a value for the line distance a of 0.5 to 6.6 μm. At this line distance visible light incident on the grating is reflected onto the oblique surfaces which together form the blazed grating, while incident EUV radiation and DUV radiation (deep ultraviolet radiation) are scattered by the grating in different orders at different angles. According to the described method visible light disappears from the beam as a result of the reflection on the grating, scattered DUV radiation is deflected to absorption bodies and at least a part of the desired radiation thus passes through an aperture arranged for this purpose.

The known spectral filter has the drawback that at least a part of the desired EUV radiation is deflected at different angles by the blazed grating as a result of higher-order diffractions, and so does not pass through in a desired direction and is lost for the intended application, for instance lithography.

It is an object of the invention to provide a spectral filter for splitting a beam of EUV radiation from a generated beam comprising parasitic IR radiation, wherein the power of the generated EUV radiation does not decrease after the separation of parasitic radiation, or only does so to negligible extent.

This object is achieved, and other advantages realized, with a spectral filter of the type specified in the preamble, in which according to the invention the multilayer structure has a pattern of at least one system of concentric grooves mutually separated by concentric rings, wherein the width and depth of the grooves and the width of the rings are selected such that the concentric grooves and rings form Fresnel zones for reflecting radiation with a wavelength in the infrared wavelength range (IR radiation) incident on these grooves and rings.

In such a spectral filter the presence of the concentric grooves, the bottoms of which are provided with the same multilayer structure as the other parts of the surface of the collimator, is not relevant for incident EUV radiation: the filter reflects an incident beam of EUV radiation in the same way as a prior art filter.

For incident parasitic IR radiation however, the grooves and rings forming the Fresnel zones function as a mirror with its own focus, the value of which is approximately determined by the following relation:

$$R_1 = \sqrt{(f_{zone}.\lambda_{IR})} \quad (1)$$

R_1 being here the radius of the first Fresnel zone,
f_{zone} the focal length of the Fresnel zones, and
λ_{IR} the wavelength of the parasitic IR radiation.

The radius of the grooves and rings forming the second and subsequent Fresnel zones is represented approximately by:

$$R_n = R_1 \sqrt{n} \quad (2)$$

in which n = 2, 3, 4, ...

Using a spectral filter provided in such a manner with Fresnel zones the parasitic IR radiation can be split from a generated beam with primary EUV radiation.

In an embodiment of a spectral filter according to the invention the multilayer structure has a pattern of a number of systems of grooves concentric to points distributed over the surface and mutually separated by concentric rings, wherein the width and depth of the grooves and the width of the rings are selected such that the concentric grooves and rings each form Fresnel zones for reflecting IR radiation incident on these grooves and rings.

The points are for instance distributed uniformly over the surface.

The presence of a number of systems with Fresnel zones in this embodiment provides particular advantage in the case of a spectral filter whose surface has a size such that the Fresnel zones of higher orders would have a mutual distance, as defined by equation (2) above, which is too small to be able to realize with available manufacturing methods.

In a preferred embodiment of a spectral filter according to the invention the surface comprises a part of a concave ellipsoidal surface which focuses EUV radiation generated in a first focus in a second focus, and the system or the systems of concentric grooves and rings, in combination with the concave surface, focus the incident IR radiation in a third focus.

Such a spectral filter is particularly suitable for application as collimator in an EUV radiation source in which the EUV radiation is generated in a plasma which is excited by IR pulses with a wavelength of typically 10.6 µ emitted by a CO_2 laser. Pulses of other wavelengths around 10.6 µ, for instance 9.6 µ, can also be generated by a CO_2 laser.

In an embodiment of a spectral filter applied for instance in an EUV radiation source, an opening for incident IR radiation is provided around the intersection of the main axis and the surface of the ellipsoid, and the at least one system of concentric grooves and rings is arranged around the intersection.

In an embodiment of a spectral filter which is particularly suitable for application in an EUV source with a plasma excited by a CO_2 laser, the third focus coincides with the first focus.

The coincidence of the third and the first focus, where the plasma is located, has the result that a part of the IR radiation incident on the plasma which has not contributed toward the excitation of the plasma but is reflected by the plasma, is incident on the collimator, is there focussed in the first focus by the Fresnel zones and the ellipsoidal surface, and can still contribute toward the excitation of the plasma. It has been found that the delay in re-focussing of the reflected IR radiation occurring here has a positive effect on the efficiency of generating EUV radiation in the plasma.

In a spectral filter according to the invention the depth of the grooves preferably amounts to at least a quarter of the wavelength of the IR radiation.

In a spectral filter according to the invention the multilayer structure is for instance formed by a stack of thin films which substantially reflect the EUV radiation, which thin films are separated by separating layers with a thickness in the order of magnitude of a quarter of the wavelength of the EUV radiation, which separating layers substantially do not reflect the EUV radiation, wherein the thin films are manufactured substantially from at least one of the materials from the groups of transition elements from the fourth, fifth and sixth period and from the series of the rare earths of the periodic system of elements, for instance cobalt (Co), nickel (Ni), niobium (Nb), molybdenum (Mo), wolfram (W), rhenium (Re), iridium (Ir) and lanthanum (La).

The separating layers are for instance manufactured from at least one of the materials from the group of lithium (Li), lithium halogenides, beryllium (Be), boron (B), boron carbide (B_4C), carbon (C), silicon (Si) and passivated silicon (Si:H).

In a practically advantageous embodiment of a spectral filter according to the invention the multilayer structure comprises a stack of thin films of molybdenum (Mo) separated by separating layers of silicon (Si).

The invention also relates to a method for manufacturing an above described spectral filter, the method comprising the successive steps of (i) providing a substrate, (ii) covering the substrate material with resist material in a pattern of at least one system of concentric rings formed around at least one point and mutually separated by uncovered parts corresponding to the concentric grooves to be etched, (iii) etching the grooves into the parts of the substrate material not covered by the resist material, (iv) removing the resist material, and (v) applying a multilayer structure.

The invention further relates to a first alternative method for manufacturing an above described spectral filter, comprising the successive steps of (i) providing a substrate, (ii) depositing an etching stop layer on the substrate, (iii) depositing a spacer layer of the substrate material on the etching stop layer, (iv) covering the spacer layer with resist material in a pattern of at least one system of concentric rings formed around at least one point and mutually separated by uncovered parts corresponding to the concentric grooves to be etched, (v) etching the grooves into the parts of the spacer layer not covered by the resist material, (vi) removing the resist material, (vii) removing the material of the etching stop layer from the grooves, and (viii) applying the multilayer structure.

According to this first alternative method the depth of the grooves can be accurately determined because the etching process stops on the etching stop layer at a depth corresponding to the thickness of the spacer layer, which must be selected such that it corresponds to the desired depth of the grooves.

According to the above described methods the substrate with the pattern of rings and grooves is manufactured by depositing rings of substrate material on a substrate, wherein the grooves are created between the rings, after which the multilayer structure is then applied to the pattern.

The invention further relates to a second alternative method for manufacturing an above described spectral filter, comprising the successive steps of (i) providing a substrate, (ii) applying a first multilayer structure to the substrate, (iii) depositing a spacer layer on the first multilayer structure, (iv) applying a second multilayer structure to the spacer layer, (v) covering the second multilayer structure with resist material in a pattern of at least one system of concentric rings formed around at least one point and mutually separated by uncovered parts corresponding to the concentric grooves to be etched, (vi) etching the grooves into the parts of the second multilayer structure and the spacer layer not covered by the resist material, and (vii) removing the resist material. The spacer layer is manufactured from a per se known material suitable for the purpose, for instance the same material from which the substrate is manufactured.

The invention further relates to a third alternative method for manufacturing an above described spectral filter, comprising the successive steps of (i) providing a substrate, (ii) applying a first multilayer structure to the substrate, (iii) depositing an etching stop layer on the first multilayer structure, (iv) depositing a spacer layer on the etching stop layer, (v) applying a second multilayer structure to the spacer layer, (vi) covering the second multilayer structure with resist material in a pattern of at least one system of concentric rings formed around at least one point and mutually separated by uncovered parts corresponding to the concentric grooves to be etched, (vii) etching the grooves into the parts of the second multilayer structure and the spacer layer not covered by the resist material, (viii) removing the resist material, and (ix) removing the material of the etching stop layer from the grooves.

According to this third alternative method the depth of the grooves can be accurately determined because the etching process stops on the etching stop layer at a depth corresponding to the thickness of the spacer layer, which must be selected such that it corresponds to the desired depth of the grooves.

According to the two latter above described methods the multilayer structure applied to the system of grooves and rings is obtained by etching a pattern into a substrate in which the multilayer structure has been prearranged at two levels. The first level, which is formed by the original substrate, here defines the bottom of the grooves and the second level, which is formed by the upper surface of the spacer layer, defines the surface of the rings on the collimator.

In an embodiment of any of the methods comprising of depositing and removing an etching stop layer, the etching stop layer comprises a layer of chromium (Cr).

In the methods according to the invention the etching process can for instance be performed as a process for reactive-ion etching, inductively coupled plasma etching or deep reactive-ion etching.

The invention will now be elucidated hereinbelow on the basis of exemplary embodiments, with reference to the drawings.

In the drawings

Fig. 1 shows a cross-sectional schematic view of a part of an EUV radiation source which is provided with a first embodiment of a collimator comprising a spectral filter according to the invention,

Fig. 2 shows in detail a part of the surface of the collimator illustrated in fig. 1, manufactured according to a first method,

Fig. 3 shows a schematic cross-sectional detail view of a part of the surface of a second embodiment of a collimator comprising a spectral filter according to the invention at successive stages of the production thereof according to a second method,

Fig. 4 shows a schematic cross-sectional detail view of a part of the surface of a third embodiment of a collimator comprising a spectral filter according to the invention at a stage of the production thereof according to a third method, and

Fig. 5 shows in a plane projection the surface of a fourth embodiment of a collimator comprising a spectral filter according to the invention.

Corresponding components are designated in the figures with the same reference numerals.

Fig. 1 shows an EUV radiation source 1 with a vacuum chamber 13 and a droplet generator 2 which generates droplets 3 of a material which, when heated and excited by a laser beam 4, successively transposes into a plasma state and emits radiation with a wavelength in the EUV range. The generated droplets 3 comprise a material, for instance tin, per se suitable for laser excitation. Laser beam 4 is for instance a beam of IR radiation with a wavelength of 10.6 μm generated by a CO_2 laser. Laser beam 4 enters through a first optical opening 5 in a collimator 6, the surface of which is ellipsoidal. The point where the heating and excitation of material droplet 3 take place, and in which the EUV radiation is thus generated, is the first focus 11 of a virtual ellipsoid 7 (with rotation axis x, half long axis *a* and half short axis *b*), of which the collimator 6 forms the real part. Surface 8 of collimator 6 is covered with a multilayer structure which reflects (arrows 10) the incident generated EUV radiation (arrows 9) and focusses it in the second or intermediary focus 12 of ellipsoid 7, which is situated in a second optical opening 15 in a rear wall 14 of vacuum chamber 13 lying opposite collimator 6. Formed in surface 8 of collimator 6 around opening 5 is a system of concentric grooves mutually separated by concentric rings which form

Fresnel zones (shown in detail in fig. 2). These Fresnel zones focus incident parasitic radiation (arrows 16), created by reflection of a part of the incident laser beam 4 on a material droplet 3 situated in first focus 11, in a third focus 17. The Fresnel zones all function here as a spectral filter and achieve that the beam 10 exiting through second focus 12 and second opening 15 is free of the undesirable parasitic radiation and comprises only the desired EUV radiation. As can be seen on the basis of the equations (1) and (2) above, the Fresnel zones can be designed such that the third focus 17 for the parasitic radiation coincides with the first focus 11 of ellipsoid 7.

Fig. 2 shows a schematic axial cross-section of a detail of collimator 6 around optical opening 5. On a substrate 18 a multilayer structure is formed from thin films 19 of molybdenum separated by separating layers 20 of silicon. Formed in multilayer structure 19, 20 around rotation axis x and optical opening 5 is a pattern of a system of concentric grooves 21, mutually separated by concentric rings 22 which form Fresnel zones for reflecting and focussing incident IR radiation. The radii R_1, R_2, R_3, ... are represented by the equations (1) and (2) above. The collimator is manufactured according to a method, according to which, successively

(i) to substrate 18,

(ii) multilayer structure 19, 20 is applied, after which

(iii) this latter is covered with resist material in the pattern of the concentric rings to be arranged, after which

(iv) grooves 21 are etched into the parts of multilayer structure 19, 20 not covered by the resist material, and

(v) the resist material is removed.

It is noted that the thickness of layers 19, 20 and the width and the depth of grooves 21 are not shown in the correct proportion. In a typical multilayer structure for a reflector for EUV radiation with a wavelength of 13.5 nm the lattice distance d, which is defined as the sum of the thicknesses of a thin film 19 and a separating layer 20, amounts to about 6.7 nm (half the wavelength of the radiation). The depth D of grooves 21 amounts to about a quarter of the wavelength of the incident IR radiation. The depth D for a groove 21 in a Fresnel zone for IR radiation with a wavelength of 10.6 µm thus amounts to about 2.65 µm, so that a ring 22 would comprise a stack of about 400 layers. It is known that a reflection of about 70% can be realized with a multilayer structure of Mo/Si comprising a stack of 50 layers and thereby a layer thickness of about 200 nm. In order to manufacture a collimator according to the invention it can thus suffice to arrange such a stack of a limited number of thin layers on a substrate in which a system of concentric grooves, mutually separated by concentric rings, is formed around at least one point, as shown in fig. 3.

Fig. 3 shows a schematic cross-sectional detail view of a part of the surface of a second embodiment of a collimator provided with a spectral filter according to the invention in successive steps of production with, from top to bottom

(i) a substrate 18, for instance of silicon (Si),

(ii) substrate 18 provided with an etching stop layer 23, for instance of chromium (Cr) or, in the case that use is made of an SOI (Silicon-On-Wafer), an SiO_2 layer

(iii) the substrate of step (ii) provided with a spacer layer 24,

(iv) the substrate of step (iii) covered with resist material 25 in a pattern of the concentric rings to be arranged,

(v) the substrate of step (iv) after etching of grooves 21 into the parts of spacer layer 24 not covered by resist material 25,

(vi) the substrate of step (v) after removal of resist material 25,

(vii) the substrate of step (vi) after removal of the material of etching stop layer 23 from grooves 21, and

(viii) the substrate of step (vii) to which multilayer structure 19, 20 is applied.

Fig. 4 shows a schematic cross-sectional detail view of a part of the surface of a third embodiment of a collimator provided with a spectral filter according to the invention at a stage of the production according to a third method, prior to the etching. According to this third method

(i) on a substrate 18,

(ii) is deposited a first multilayer structure 19, 29, after which

(iii) an etching stop layer 23 is deposited on the first multilayer structure 19, 29, and

(iv) a spacer layer 24 is deposited on etching stop layer 23, after which

(v) a second multilayer structure 19, 20 is applied to spacer layer 24,

(vi) the second multilayer structure 19, 20 is covered with resist material 25 in the pattern of the desired concentric rings,

(vii) grooves are etched into the parts of the second multilayer structure 19, 20 and spacer layer 24 not covered by the resist material 25, after which

(viii) the resist material 24 is removed, and

(ix) the material of etching stop layer 23 is removed from the grooves.

Fig. 5 shows in a plane projection the surface of a fourth embodiment of an ellipsoidal collimator 26 provided with a spectral filter, wherein a first central system of concentric rings 22 and grooves 21 is arranged around the central optical opening 5, and wherein subsequent systems of concentric rings 22 and grooves 21 are arranged uniformly distributed over the surface around this central system, wherein the surface of each ring 22 and each groove 21 is covered with a multilayer structure, wherein each system functions as Fresnel zones which are dimensioned such that they have a common focus which lies on the rotation axis of the ellipsoid of which collimator 26 forms the real part.

It is noted that the invention is not limited to the above stated exemplary embodiments in which a spectral filter is applied in an EUV radiation source, in which an incident beam of IR radiation with a wavelength of 10.6 μm is generated by a CO_2 laser. The invention likewise relates to spectral filters for separating EUV radiation or soft X-Ray radiation and IR radiation with wavelengths other than those generated by a CO_2 laser, such as for instance the radiation of an Nd:YAG laser, with a typical wavelength of 1.064 μm, or the radiation which is generated by an excimer laser and which can be applied for the purpose of exciting a plasma and thereby generating EUV or soft X radiation.

CLAIMS

1. Spectral filter (6, 26) for splitting the primary radiation from a generated beam with primary electromagnetic radiation having a wavelength in the extreme ultraviolet (EUV radiation) or soft X-ray (soft X) wavelength range and parasitic radiation having a wavelength in the infrared wavelength range (IR radiation) in an optical device, comprising a surface for reflecting electromagnetic radiation with a wavelength in the extreme ultraviolet wavelength range (EUV radiation), the surface being formed by an EUV radiation or soft X-ray-reflecting multilayer structure (19, 20), characterized in that the multilayer structure (19, 20) has a pattern of at least one system of concentric grooves (21) mutually separated by concentric rings (22), wherein the width and depth of the grooves (21) and the width of the rings (22) are selected such that the concentric grooves (21) and rings (22) form Fresnel zones for reflecting radiation with a wavelength in the infrared wavelength range (IR radiation) incident on these grooves (21) and rings (22).

2. Spectral filter (6, 26) as claimed in claim 1, characterized in that the multilayer structure (19, 20) has a pattern of a number of systems of grooves (21) concentric to points distributed over the surface and mutually separated by concentric rings (22), wherein the width and depth of the grooves (21) and the width of the rings (22) are selected such that the concentric grooves (21) and rings (22) each form Fresnel zones for reflecting IR radiation incident on these grooves (21) and rings (22).

3. Spectral filter (6, 26) as claimed in claim 2, characterized in that the points are distributed uniformly over the surface.

4. Spectral filter (6, 26) as claimed in any of the claims 1-3, wherein the surface comprises a part of a concave

ellipsoidal (7) surface which focuses EUV radiation generated in a first focus (11) in a second focus (12), characterized in that the system or the systems of concentric grooves (21) and rings (22) focus the incident IR radiation in a third focus (17).

5. Spectral filter (6) as claimed in claim 4, wherein an opening (5) for incident IR radiation (4) is provided around the intersection of the main axis (x) and the surface of the ellipsoid (7), characterized in that the at least one system of concentric grooves (21) and rings (22) is arranged around the intersection.

6. Spectral filter (6) as claimed in any of the claims 4-5, characterized in that the third focus (17) coincides with the first focus (11).

7. Spectral filter (6, 26) as claimed in any of the claims 1-6, characterized in that the depth (D) of the grooves (21) amounts to at least a quarter of the wavelength of the IR radiation.

8. Spectral filter (6, 26) as claimed in any of the claims 1-7, wherein the multilayer structure (19, 20) is formed by a stack of thin films (19) which substantially reflect the EUV radiation, which thin films (19) are separated by separating layers (20) with a thickness in the order of magnitude of a quarter of the wavelength of the EUV radiation, which separating layers substantially do not reflect the EUV radiation, characterized in that the thin films (19) are manufactured substantially from at least one of the materials from the groups of transition elements from the fourth, fifth and sixth period and from the series of the rare earths of the periodic system of elements.

9. Spectral filter (6, 26) as claimed in claim 8, characterized in that the thin films (19) are manufactured substantially from at least one of the materials cobalt (Co), nickel (Ni), niobium (Nb), molybdenum (Mo), wolfram (W), rhenium (Re), iridium (Ir) and lanthanum (La).

10. Spectral filter (6, 26) as claimed in any of the claims 8-9, characterized in that the separating layers (20) are manufactured from at least one of the materials from the group of lithium (Li), lithium halogenides, beryllium (Be), boron (B), boron carbide (B_4C), carbon (C), silicon (Si) and passivated silicon (Si:H).

11. Spectral filter (6, 26) as claimed in claim 8, characterized in that the multilayer structure (19, 20) comprises a stack of thin films (19) of molybdenum (Mo) separated by separating layers (20) of silicon (Si).

12. Method for manufacturing a spectral filter (6, 26) as claimed in any of the claims 1-11, comprising the successive steps of

(i) providing a substrate (18),

(ii) covering the substrate material (18) with resist material (25) in a pattern of at least one system of concentric rings (22) formed around at least one point and mutually separated by uncovered parts corresponding to the concentric grooves (21) to be etched,

(iii) etching the grooves (21) into the parts of the substrate material (18) not covered by the resist material (25),

(iv) removing the resist material (25), and

(v) applying a multilayer structure (19, 20).

13. Method for manufacturing a spectral filter (6, 26) as claimed in any of the claims 1-11, comprising the successive steps of

(i) providing a substrate (18),

(ii) depositing an etching stop layer (23) on the substrate (18),

(iii) depositing a spacer layer (24) on the etching stop layer (23),

(iv) covering the spacer layer (24) with resist material (25) in a pattern of at least one system of concentric rings (22) formed around at least one point and mutually separated by uncovered parts corresponding to the concentric grooves (21) to be etched,

(v) etching the grooves (21) into the parts of the spacer layer (24) not covered by the resist material (25),

(vi) removing the resist material (25),

(vii) removing the material of the etching stop layer (23) from the grooves (21), and

(viii) applying the multilayer structure (19, 20).

14. Method for manufacturing a spectral filter (6, 26) as claimed in any of the claims 1-11, comprising the successive steps of

(i) providing a substrate (18),

(ii) applying a first multilayer structure (19, 20) to the substrate (18),

(iii) depositing a spacer layer (24) on the first multilayer structure (19, 20),

(iv) applying a second multilayer structure (19, 20) to the spacer layer (24),

(v) covering the second multilayer structure (19, 20) with resist material (25) in a pattern of at least one system of concentric rings (22) formed around at least one point and mutually separated by uncovered parts corresponding to the concentric grooves (21) to be etched,

(vi) etching the grooves (21) into the parts of the second multilayer structure (19, 20) and the spacer layer (24) not covered by the resist material (25), and

(vii) removing the resist material (25).

15. Method for manufacturing a spectral filter (6, 26) as claimed in any of the claims 1-11, comprising the successive steps of

(i) providing a substrate (18),

(ii) applying a first multilayer structure (19, 20) to the substrate (18),

(iii) depositing an etching stop layer (23) on the first multilayer structure (19, 20),

(iv) depositing a spacer layer (24) on the etching stop layer (23),

(v) applying a second multilayer structure (19, 20) to the spacer layer (24),

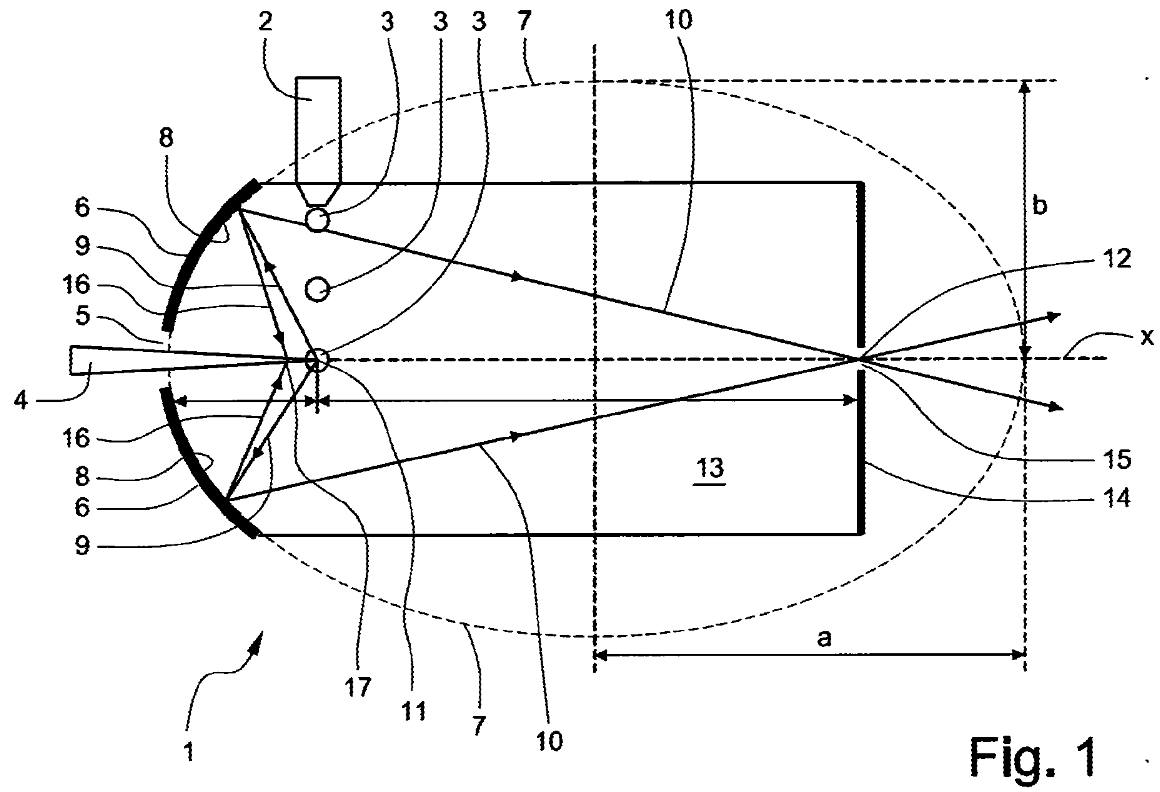
(vi) covering the second multilayer structure (19, 20) with resist material (25) in a pattern of at least one system of concentric rings (22) formed around at least one point and mutually separated by uncovered parts corresponding to the concentric grooves (21) to be etched,

(vii) etching the grooves (21) into the parts of the second multilayer structure (19, 20) and the spacer layer (24) not covered by the resist material (25),

(viii) removing the resist material (25), and

(ix) removing the material of the etching stop layer (23) from the grooves (21).

16. Method as claimed in either of the claims 13 or 15, characterized in that the etching stop layer (23) comprises a layer of chromium (Cr).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6
9
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9
b
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x
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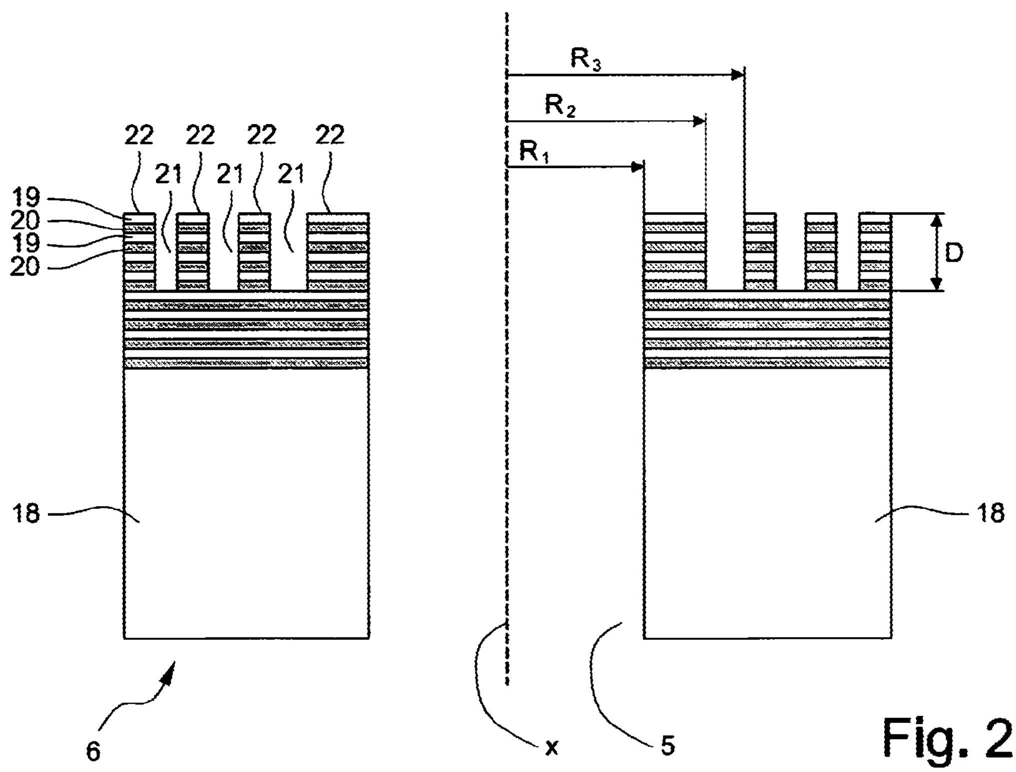
14
13
a
1
17
11
7
10

Fig. 1


22
22
22
22
21
21
21
19
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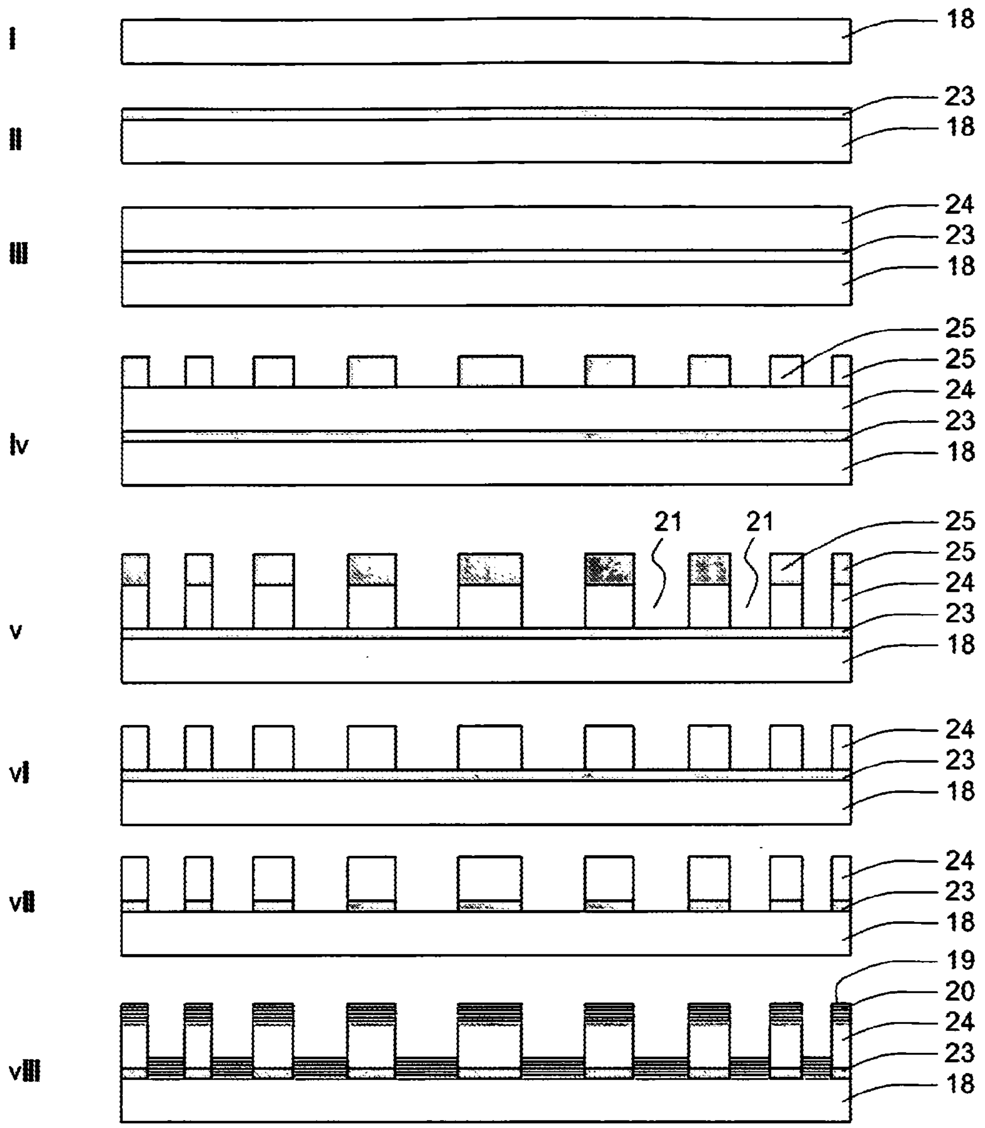
20
18
6
R_3
R_2
R_1
D
18
x
5

Fig. 2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viii
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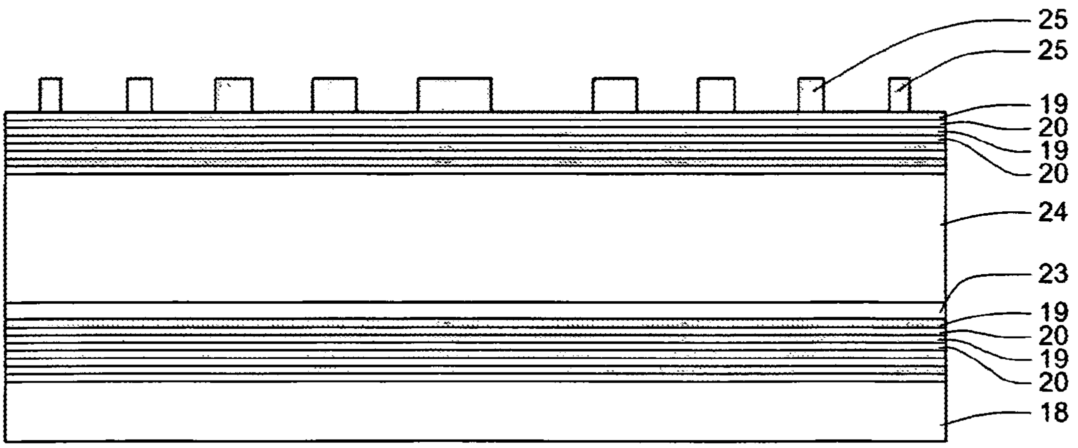
18

Fig. 3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18

Fig. 4

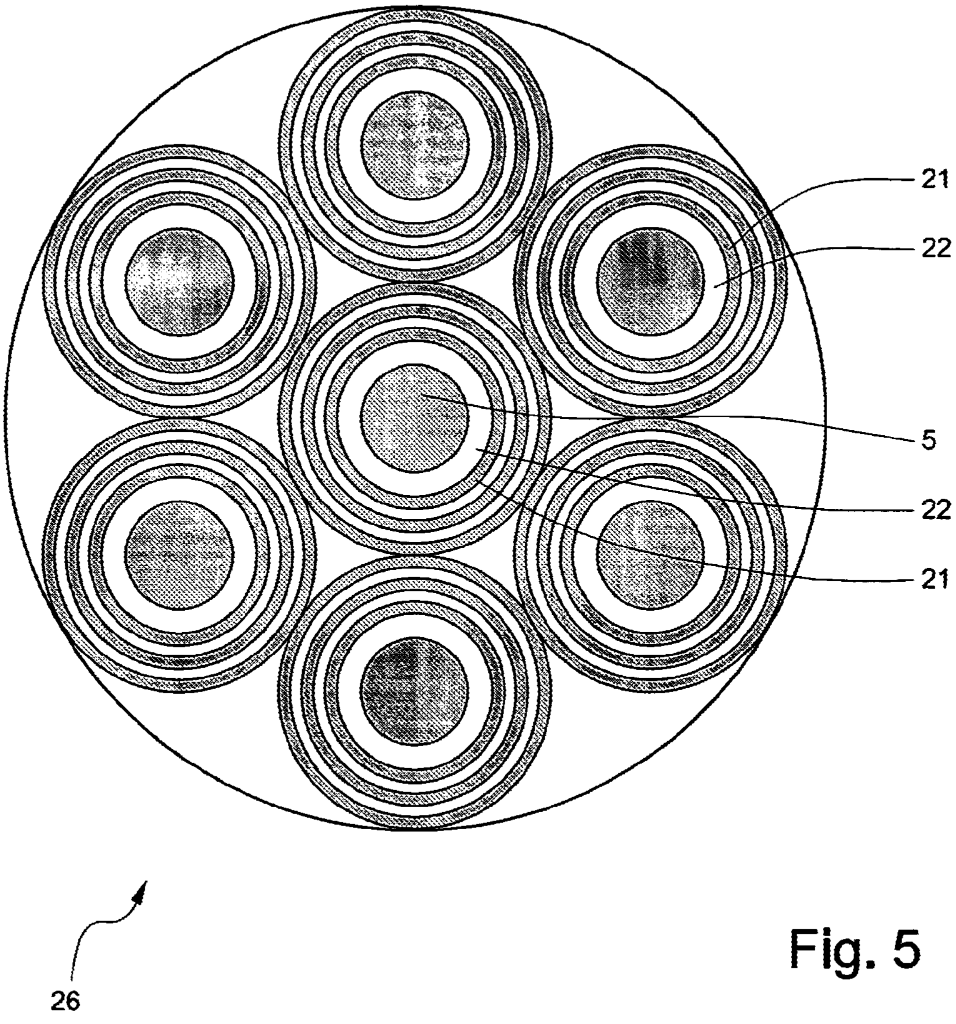

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2011/050565

A. CLASSIFICATION OF SUBJECT MATTER
INV. G02B5/18 G02B5/20 G02B27/10 G03F7/20 H05G2/00
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 G21K G02B H05G

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	ULF KLEINEBERG, HANS-JUERGEN STOCK, D. MENKE, K. OSTERRIED, BERNT SCHMIEDESKAMP, ULRICH HEINZMANN, DETLEF FUCHS: "Multilayer reflection-type zone plates and blazed gratings for the normal incidence soft x-ray region", PROC. SPIE, vol. 2279, 1994, pages 269-282, XP002629279, DOI: 10.1117/12.193143 pages 270-271 ----- -/--	1,7-16

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

[X] See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 September 2011	04/11/2011

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Serbin, Jesper

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2011/050565

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	A. J. R. VAN DEN BOOGAARD, E. LOUIS, F. A. VAN GOOR AND F. BIJKERK: "Optical element for full spectral purity from IR-generated EUV light sources", ALTERNATIVE LITHOGRAPHIC TECHNOLOGIES, vol. 7271, 72713B, 18 March 2009 (2009-03-18), pages 1-6, XP002628986, figure 2 pages 1-3 -----	1-16
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A	DAVID C. BRANDT, IGOR V. FOMENKOV, ALEX I. ERSHOV, WILLIAM N. PARTLO, DAVID W. MYERS: "LPP source system development for HVM", PROC. SPIE, vol. 7636, no. 76361I, 20 March 2010 (2010-03-20), page 1, XP040519774, DOI: 10.1117/12.848404 figure 1 -----	1-16
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/NL2011/050565

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