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(54) Title: DEVICE AND METHOD FOR SHIELDING COMPONENTS TO BE THERMALLY INSULATED IN MICROLITHOGRAPHIC PROJECTION EXPOSURE APPARATUSES

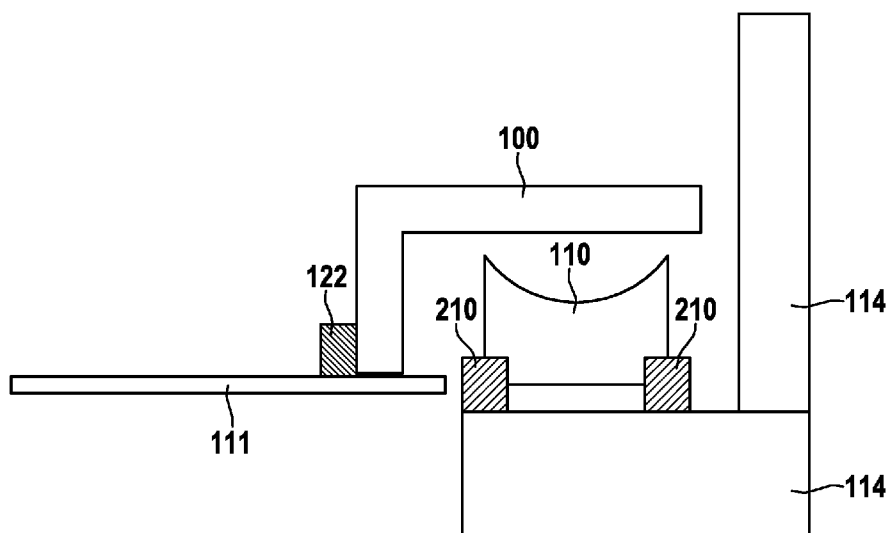


Fig. 1b

(57) Abstract: The invention relates to a microlithographic projection exposure apparatus, in particular for the DUV range (400) or for the EUV range (300), comprising a movable shield (100) and at least one component (110, 210) to be thermally insulated. The movable shield (100) is configured, in an operating pause of the microlithographic projection exposure apparatus (300, 400), for example in the case of maintenance, to lengthen the time duration in which the temperature of the component (110, 210) to be thermally insulated approaches the ambient temperature. The invention additionally relates to a method for thermally insulating at least one component (110, 210) of a microlithographic projection exposure apparatus (300, 400). Firstly, the light source (301, 406) is switched off or shaded in an operating pause of the microlithographic projection exposure apparatus (300, 400). Afterward, the movable shield (100) is moved



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from a rest position into a functional position in such a way that in the functional position the component (110, 210) to be thermally insulated is enclosed at least regionally by the movable shield (100).

Device and method for shielding components to be thermally insulated in microlithographic projection exposure apparatuses

Background of the invention

The present invention relates to a shield for thermally insulating components in microlithographic projection exposure apparatuses. The invention additionally relates to a method for thermally insulating components in microlithographic projection exposure apparatuses.

Microlithography is used for producing microstructured components such as, for example, integrated circuits or LCDs. The microlithography process is conducted in what is called a projection exposure apparatus, which comprises an illumination device and a projection lens. The image of a mask (= reticle) illuminated by means of the illumination device is projected here by means of the projection lens onto a substrate (e.g. a silicon wafer) coated with a light-sensitive layer (= photoresist) and disposed in the image plane of the projection lens, in order to transfer the mask structure to the light-sensitive coating of the substrate.

The terms microlithographic projection exposure apparatus, projection exposure apparatus, (EUV or DUV) system and lithographic scanner are used synonymously hereinafter.

In projection lenses designed for the DUV range, i.e. at wavelengths of e.g. 193 nm or 248 nm, lens elements are preferably used as optical elements for the imaging process. In order to achieve a higher resolution of lithographic optical units, projection lenses designed for the EUV range have been used for some years, said projection lenses being operated at wavelengths of e.g. approximately 13.5 nm or 7 nm.

In such projection lenses designed for the EUV range, owing to the lack of availability of suitable light-transmissive refractive materials, mirrors are used as optical elements for the imaging process. Said mirrors operate either with almost normal incidence or with grazing incidence. Mirrors, on account of their reflective effect on light rays, are significantly more position-sensitive than lens elements. In this regard, a mirror tilt with a factor of 2 is translated into a change in ray direction, while what typically occurs in the case of a lens element is a

considerable compensation of the change in the refractive ray direction influence between front and rear sides.

A significant influence on the mirror shape originates from the thermal expansion of the mirror material. Materials having low coefficients of thermal expansion such as Zerodur or ULE (ultra low expansion) are therefore used for EUV mirrors. Such materials react to temperature changes significantly more weakly than glasses or quartz glass. Nevertheless, considerable error contributions can occur within the scope of the available aberration budget. Said error contributions are composed of effects of an inhomogeneous temperature distribution and inhomogeneities of the so-called zero crossing temperature (ZCT) in the volume of the material, for instance on account of a varying stoichiometry between SiO_2 and TiO_2 in the ULE material. Both local and global temperature changes vis-à-vis an envisaged operating temperature of the microlithographic projection exposure apparatus can cause aberrations, which can be corrected by manipulators only in part.

The operating state is often defined by an assumed maximum power of the EUV system at the operating wavelength, that is to say for example at a wavelength of 13.5 nm. If said maximum power is not reached, for instance because a reticle that is less highly reflective on average is used, then for example in accordance with the prior art infrared heaters can effect "top-up" heating and ensure that the mirrors are operated close to the averaged zero crossing temperature, where they are particularly insensitive on account of the quadratic deformation dependence on the temperature difference with respect to this temperature.

One important quality feature of lithographic scanners is the active time thereof, in which semiconductor components can actually be fabricated with high yield ("uptime"). For various reasons, however, maintenance work will be necessary from time to time, in the course of which the lithographic scanner is opened and e.g. an inspection, cleaning or exchange of parts is carried out. Whereas a high thermal stability is attained in the closed lithographic scanner in a vacuum, when the lithographic scanner has been opened components such as the mirrors, for example, are in contact with the clean room atmosphere. The clean room atmosphere may have comparatively high temperature tolerances, that is to say may be significantly colder or hotter than the operating temperature of preferably 22°C, for example, in the interior of the lithographic scanner.

In the course of the maintenance work, the temperature of the components, in particular of the mirrors, adapts to the temperature of the clean room atmosphere. The longer the lithographic scanner is open, that is to say the greater the length of the maintenance window, the more greatly the temperature of the mirrors adapts to the temperature of the clean room atmosphere. Once the maintenance work has ended, the temperature of the mirrors may deviate considerably from the envisaged operating temperature thereof. What is then correspondingly higher is the sensitivity thereof to local temperature variations such as may be established at the latest during operation on account of inhomogeneous illumination given EUV-typical absorption coefficients of between 15% in the case of grazing incidence of the EUV light and 40% in the case of normal incidence of the EUV light. At the same time, the local differences in the coefficient of thermal expansion take effect to an intensified degree. In summary, there is an increased aberration level that is unacceptable for a high product yield.

The terms temperature of the clean room atmosphere and ambient temperature are used synonymously hereinafter.

After the lithographic scanner has been closed and started up again, the temperature of the mirrors will gradually be adjusted to the envisaged values again, partly under the influence of the mirror heaters mentioned above. Since the mirrors constitute large and voluminous optical parts, they have time constants of a few hours to a few days for their temperature to readapt. The high volume stems from a high corrected etendue, the partial use of grazing incidence mirrors (the oblique section through a light pipe has a higher area than the perpendicular section) and also the need to realise a considerable mirror thickness for the purpose of high stiffnesses. Said high stiffness protects against deformations upon the introduction of forces and moments for position correction and optimization of the mirrors during operation. In summary, the high time constants necessitate considerable waiting times of the lithographic scanner following maintenance windows before the lithographic scanner reaches its full performance again. The quality criterion of active time "suffers".

In view of the problems described above, the object established is that of providing a device and a method which solve the problems mentioned above, in particular shorten the waiting times of the lithographic scanner following maintenance windows.

According to the invention, the aforementioned object is achieved by means of a microlithographic projection exposure apparatus, in particular for the DUV range or for the EUV range, comprising at least one movable shield and comprising at least one component to be thermally insulated. The at least one movable shield is configured, in an operating pause of the microlithographic projection exposure apparatus, for example in the case of maintenance, to lengthen the time duration in which the temperature of the at least one component to be thermally insulated approaches the ambient temperature. This is particularly advantageous since, as a result, after the microlithographic projection exposure apparatus has been started up again, its active time is lengthened.

In one embodiment, the component to be thermally insulated comprises at least one mirror. The mirror is designed for reflecting electromagnetic radiation from the EUV range. The application of the invention to a mirror is particularly advantageous since mirrors, as set out above, react particularly "sensitively" to temperature changes.

In one embodiment, the component to be thermally insulated comprises at least one mount technology element. For a multiplicity of applications it is necessary for the mount technology, surrounding the optical element, and/or the actuator system contact-connected to the optical element to be kept as stable as possible thermally during the repair or swap process. The application of the invention to mount technology elements is particularly advantageous. In the present application, the term mount technology element encompasses the mount technology and/or the actuator system contact-connected to the optical element. In this case, the mount technology elements can be passive or actuatable.

In one embodiment, the material of the movable shield comprises at least one thermal insulator. Owing to its low thermal conductivity, a thermal insulator is particularly well suited to heat insulation. In the present case, heat insulation is taken to mean the thermal shielding of the component, specifically both for the case where, when the microlithographic projection exposure apparatus is opened, the temperature of the component is higher than the ambient temperature, and for the case where the temperature of the component is lower than the ambient temperature. The choice of a thermal insulator is advantageous since, as a result, the temperature of the shielded component approaches the ambient temperature particularly slowly. The shield can comprise for example PTFE (polytetrafluoroethylene, thermal conductivity $0.24 \text{ W/(m}\cdot\text{K)}$),

POM (polyoxymethylene, thermal conductivity 0.31 W/(mK)) and/or a silicate ceramic (thermal conductivity 2-4 W/mK).

In order to further improve the heat insulation, the movable shield, on its side facing the component to be thermally insulated, can be provided with at least one coating that is at least partly reflective to electromagnetic radiation in the infrared range. Additionally or alternatively, the movable shield, on its side facing away from the component to be thermally insulated, can be provided with at least one coating that at least partly reflects the electromagnetic radiation in the infrared range emanating from the surroundings. As a result, the heating of the movable shield can advantageously be slowed down.

In one embodiment, the movable shield encloses the component to be thermally insulated at least regionally and/or at least at times in the operating pause of the microlithographic projection exposure apparatus. This is advantageous since in this way only a further reduced exchange between a volume, formed by the region between component and shield, and the clean room atmosphere takes place.

In one embodiment, the movable shield is spaced apart from the component to be thermally insulated at a distance of between 1 mm and 20 mm, preferably at a distance of between 2 mm and 5 mm, in the operating pause of the microlithographic projection exposure apparatus. The range of values mentioned above is advantageous since, on the one hand, in the operating pause the movable shield is intended to be arranged as near as possible to the component to be thermally insulated, but on the other hand the distance must be large enough in order that, during introduction and during movement back again, the movable shield does not collide with the component to be thermally insulated.

In one embodiment, the movable shield has at least one cavity filled with a fluid, preferably a gas, in particular air. This is advantageous since, as a result, the thermal conductivity can be reduced further. In other words, the heat insulation is improved further by comparison with a shield without fluid-filled cavities.

After the microlithographic projection exposure apparatus has been opened, the temperature of the movable shield itself also approaches the ambient temperature slowly as a result of the absorption of the infrared radiation emanating from the component to be thermally insulated and/or as a result of the contact with the clean room atmosphere. This approach occurs all the

more slowly, the lower the thermal conductivity. The following equation holds true for the time constant associated therewith:

$$\tau = (mc_p)/\alpha A_O$$

In this case, m denotes the mass of the shield, c_p denotes the specific heat capacity thereof, α denotes the heat transfer coefficient thereof, and A_O denotes the surface area thereof.

In various embodiments, the movable shield is developed in order to be able to influence its heat insulation in an advantageous manner. For this purpose, measures are proposed for regulating the temperature of the movable shield, in particular in its functional position, that is to say when the lithographic scanner has been opened. Temperature regulating here explicitly means heating and/or cooling. In this regard, if there are a plurality of movable shields in a single lithographic scanner, the movable shields can be temperature-regulated differently.

Specifically, the shield can be temperature-regulated by the contact with a heat accumulator. The heat accumulator can contain a substance, in particular a wax, which is converted from a solid to a liquid state of matter as a result of the absorption of latent heat of fusion (= enthalpy of fusion). A reservoir is kept available for the substance. Once the substance has melted in its entirety, the reservoir is replaced.

Alternatively or additionally, a temperature-regulating medium can flow in the volume of the movable shield. For this purpose, it is necessary for cavities, in particular pipes, to be formed in the interior of the movable shield, with the temperature-regulating medium flowing in them.

Alternatively or additionally, piping can be arranged on the surface of the movable shield. The piping can have a meandering structure and be soldered on. The temperature-regulating medium is guided in the pipes.

Alternatively or additionally, it is possible to achieve an electrical heating of the movable shield by electrical resistance wires in and/or on the movable shield.

In one embodiment, the microlithographic projection exposure apparatus is embodied in such a way that in the operating pause, in particular at the beginning of the operating pause, the

movable shield, for example by means of an actuator, is slidable and/or foldable from a rest position in the direction of the component to be thermally insulated into a functional position. In the rest position of the shield, the light source, in particular the EUV light source, is switched on and is relayed by the mirror system of the microlithographic projection exposure apparatus to the wafer. In the functional position of the shield, the light source is switched off or shaded and the microlithographic projection exposure apparatus is at least partly opened.

In one embodiment, the movable shield comprises at least one flexure, in particular a rotary joint, and/or a leg spring. This is advantageous since, particularly during the movement of the flexure, no abrasion occurs and, consequently, no contaminants arise in the microlithographic projection exposure apparatus.

In one embodiment, the movable shield is moved along a guide arranged outside an optical used region of the microlithographic projection exposure apparatus. The movement is preferably effected along at least one guide rail. This is advantageous since the abrasion that possibly arises during the movement is at least partly kept away from the optical used region.

In one embodiment, at least one additional temperature-regulating source is provided. Preferably, the temperature-regulating source is an infrared radiator. The use of the additional temperature-regulating source can advantageously be combined with all the measures mentioned above for regulating the temperature of the movable shield.

The operating temperature of a microlithographic projection exposure apparatus in the EUV range is approximately 22°C. However, the operating temperature of the mirrors to be thermally insulated can deviate from 22°C. 15°C to 29°C is specified as a tolerance range for the mirror temperature. The operating temperatures of the various mirrors in one and the same microlithographic projection exposure apparatus can deviate from one another within the scope of the tolerance range mentioned above.

According to the invention, the object mentioned above is also achieved by means of a method for thermally insulating at least one component of a microlithographic projection exposure apparatus. This method can be carried out in accordance with two alternative embodiments: Firstly, the light source is switched off or shaded e.g. in an operating pause of the microlithographic projection exposure apparatus.

In a first embodiment, afterward the at least one movable shield is preferably moved by the action of an actuator from a rest position into a functional position, specifically in such a way that in the functional position the component to be thermally insulated is enclosed at least regionally by the movable shield. Afterward, the microlithographic projection exposure apparatus can be opened at least regionally, in particular for repair purposes. After the repair, the microlithographic projection exposure apparatus can be closed again. Afterward, the movable shield can preferably be moved back from the functional position to the rest position by the use of an actuator.

In an alternative second embodiment, directly after the light source has been switched off or shaded, the microlithographic projection exposure apparatus is opened at least regionally. It is only after the opening that the at least one movable shield is moved from a rest position into a functional position as promptly as possible. This movement of the shield can be effected by means of an actuator or manually. After the repair, the movable shield can be moved back from the functional position into the rest position by means of an actuator or manually. Afterward, the microlithographic projection exposure apparatus can be closed again.

In both the alternative embodiments, finally, the light source can be switched on again or the shading can be removed again.

After the above method steps have been carried out, the microlithographic projection exposure apparatus, following an opening, is ready for operation again more rapidly than without the use of the movable shields.

Brief description of the figures

Various exemplary embodiments are explained in more detail below with reference to the figures. The figures and the relative sizes of the elements illustrated in the figures in relation to one another should not be regarded as to scale. Rather, individual elements may be illustrated with exaggerated size or size reduction in order to enable better illustration and for the sake of better understanding.

Figure 1a shows a schematic illustration of an excerpt from a microlithographic projection exposure apparatus according to the invention with a slidable shield in the rest position.

Figure 1b shows a schematic illustration of an excerpt from a microlithographic projection exposure apparatus according to the invention with a slidable shield in the functional position.

Figure 2a shows a schematic illustration of an excerpt from a microlithographic projection exposure apparatus according to the invention with a foldable shield in the rest position.

Figure 2b shows a schematic illustration of an excerpt from a microlithographic projection exposure apparatus according to the invention with a foldable shield in the functional position.

Figure 3 shows a schematic illustration of an excerpt from a microlithographic projection exposure apparatus according to the invention with a shield having been slid in, and with an additional temperature-regulating source.

Figures 4, 5, 6, 7, 8, 9 each show schematic illustrations of an excerpt from a microlithographic projection exposure apparatus according to the invention with a shield having been slid in, in the functional position.

Figure 10a shows a schematic illustration of an excerpt from a microlithographic projection exposure apparatus according to the invention with a shield having been folded in, in the functional position in a sectional view.

Figure 10b shows a schematic illustration of a mirror in plan view with associated mount technology elements without a foldable movable shield.

Figure 10c shows a schematic illustration of a mirror in plan view with associated mount technology elements with a shield having been folded in, in the functional position.

Figure 11a shows a schematic illustration of a microlithographic projection exposure apparatus according to the invention for the EUV range with a foldable shield in the rest position.

Figure 11b shows a schematic illustration of a microlithographic projection exposure apparatus according to the invention for the EUV range with a shield having been folded in, in the functional position.

Figure 12a shows a schematic illustration of a microlithographic projection exposure apparatus according to the invention for the DUV range with a foldable shield in the rest position.

Figure 12b shows a schematic illustration of a microlithographic projection exposure apparatus according to the invention for the DUV range with a shield having been folded in, in the functional position.

Best way of embodying the invention

Figure 1a shows a schematic illustration of an excerpt from a microlithographic projection exposure apparatus according to the invention for the DUV range 400 or for the EUV range 300 with a slidable movable shield 100 in the rest position. The movable shield 100 and a component 110 to be thermally insulated are illustrated, inter alia. In the present case, the component 110 to be thermally insulated is a mirror, in particular designed for reflecting electromagnetic radiation from the EUV range. The mirror 110 is held and/or actuated by mount technology elements 210 possessing a mechanism and/or an actuator system. The mount technology elements 210 themselves are linked to a carrying structure 114 and are carried by the latter. The at least one movable shield 100 is configured, in an operating pause of the microlithographic projection exposure apparatus 300, 400, for example in the case of maintenance, to lengthen the time duration in which the temperature of the component 110 to be thermally insulated approximates to the ambient temperature. The material of the movable shield 100 comprises at least one thermal insulator, preferably PTFE and/or POM and/or a silicate ceramic. The movable shield 100 is guidable along a guide rail 111, which is preferably arranged outside an optical used region. The movable shield 100 is preferably moved by an actuator 122. However, manual movement of the movable shield 100 without the use of an actuator 122 is also possible.

Figure 1b shows a schematic illustration of an excerpt from a microlithographic projection exposure apparatus according to the invention for the DUV range 400 or for the EUV range 300 with the shield 100, which is slidable on the rail 111 in the functional position. In an operating pause of the microlithographic projection exposure apparatus 400, 300, in particular at the beginning of the operating pause, the movable shield 100 is moved, in particular by the actuator 122, from the rest position in the direction of the component 110 to be thermally insulated into a functional position. In the operating pause of the microlithographic projection exposure apparatus, the movable shield 100 encloses the component 110 to be insulated at least regionally and/or at least at times. The movable shield 100 is spaced apart from the component 110 to be thermally insulated at a distance of between 1 mm and 20 mm, preferably at a distance of between 2 mm and 5 mm, in the operating pause of the microlithographic projection exposure apparatus.

Figure 2a shows a schematic illustration of an excerpt from a microlithographic projection exposure apparatus 400, 300 according to the invention with a foldable movable shield 100 in the rest position. The movable shield 100 comprises a flexure 102 embodied for example as a

rotary joint, and/or a leg spring. An actuator 122 is provided in order to fold the movable shield 100 from the rest position into the functional position.

Figure 2b shows a schematic illustration of an excerpt from a microlithographic projection exposure apparatus 400, 300 according to the invention with a folded movable shield 100 in the functional position. In the operating pause of the microlithographic projection exposure apparatus, in particular at the beginning of the operating pause, the movable shield 100 is folded from a rest position in the direction of the component 110 to be thermally insulated into a functional position by means of an actuator 122 or alternatively manually.

Figure 3 shows a schematic illustration of an excerpt from a microlithographic projection exposure apparatus 400, 300 according to the invention with a movable shield 100 having been slid in, and with an additional temperature-regulating source 104. The additional temperature-regulating source 104 can be embodied as an infrared (106) radiator, for example, which regulates the temperature of the region between the movable shield 100 and the component 110 to be insulated.

Figure 4 shows a schematic illustration of an excerpt from a microlithographic projection exposure apparatus 400, 300 according to the invention with a movable shield 100 having been slid in, wherein the movable shield 100 has cavities 108 in its volume. The cavities 108 can be filled with a fluid 109, in particular with aid, in order advantageously to further reduce the thermal conductivity of the movable shield 100.

Figure 5 shows a schematic illustration of an excerpt from a microlithographic projection exposure apparatus 400, 300 according to the invention with a movable shield 100 having been slid in, wherein a temperature-regulating medium 119, preferably water or air, flows through the cavities 108. The temperature of the movable shield 100 can be set, that is to say both heated and cooled, by means of the temperature-regulating medium 119.

Figure 6 shows a schematic illustration of an excerpt from a microlithographic projection exposure apparatus according to the invention with a movable shield 100 having been slid in, wherein the movable shield 100, particularly in its volume, has electrically conductive heating wires 107. Said heating wires 107 are preferably arranged regularly.

Figure 7 shows a schematic illustration of an excerpt from a microlithographic projection exposure apparatus according to the invention with a movable shield 100 having been slid in, wherein the movable shield 100 is in contact with a heat accumulator 105. The movable shield 100 can be temperature-regulated by the contact with the heat accumulator 105.

Figure 8 shows a schematic illustration of an excerpt from a microlithographic projection exposure apparatus according to the invention with a movable shield 100 having been slid in, wherein the temperature-regulating medium 119, preferably air or water, flows in piping 103, which is soldered onto the movable shield 100.

Figure 9 shows a schematic illustration of an excerpt from a microlithographic projection exposure apparatus according to the invention with a shield 100 having been slid in, in the functional position. The movable shield 100, on its side facing the component 110 to be thermally insulated, has a coating 101 that is at least partly reflective to the electromagnetic radiation in the infrared range emanating from the component 110 to be thermally insulated. Additionally or alternatively, the movable shield 100, on its side facing away from the component 110 to be thermally insulated can have a coating 113 that at least partly reflects the electromagnetic radiation in the infrared range emanating from the surroundings.

Figure 10a shows a schematic illustration of an excerpt from a microlithographic projection exposure apparatus according to the invention with a movable shield 100 having been folded in or pivoted in 140, in the functional position in the sectional view. After having been folded in, the movable shield 100 can be linearly positioned 130. The linear positionability 130 makes it possible to set the distance between the shield 100 and the elements 210 to be thermally insulated. In the present case, the components 210 to be thermally insulated are mount technology elements. A movable cover 100 is shown, which surrounds the optical element 110 at the periphery and covers the mount technology elements 210 at least regionally. In the present exemplary embodiment, a mount technology element 210 is understood to be a mechanism or an actuator system which is contact-connected to the optical element 110 or adjoins the optical element. The figure shows, as already mentioned above, the (linear) positioning direction 130 of the cover 100 and the pivoting direction 140 of the cover 100. Two additional temperature-regulating sources 104 are shown, the function of which has already been explained in the exemplary embodiment in Figure 3. Of course, the invention is also able to be implemented without additional temperature-regulating sources 104.

Figure 10b shows a schematic illustration of a mirror 110 in plan view with associated mount technology elements 210 without a foldable shield or with the foldable shield 100 (not shown in Figure 10b), in the rest position.

Figure 10c shows a schematic illustration of a mirror in plan view with associated mount technology elements 210 with a shield 100 having been pivoted in, in the functional position. The mount technology elements 210 are almost completely covered by the movable shield 100. The movable shield 100 has a ring shape and extends completely around the optical element 110. The mount technology elements 210 are thus thermally shielded almost completely.

Figure 11a shows a schematic illustration of a microlithographic projection exposure apparatus according to the invention for the EUV range 300 with a foldable movable shield 100 in the rest position. An illumination device comprising a field facet mirror 303 and a pupil facet mirror 304 is shown. The light from a light source unit comprising a plasma light source 301 and a collector mirror 302 is directed onto the field facet mirror 303. A first telescope mirror 305 and a second telescope mirror 306 are arranged in the light path downstream of the pupil facet mirror 304. A grazing incidence mirror 307 is arranged downstream in the light path, said grazing incidence mirror directing the radiation that is incident thereon onto an object field in the object plane of a projection lens comprising six mirrors 351-356. At the location of the object field, a reflective structure-bearing mask 321 is arranged on a mask stage 320, said mask being imaged with the aid of the projection lens into an image plane in which a substrate 361 coated with a light-sensitive layer (photoresist) is situated on a wafer stage 360. The force frame 380, which substantially carries the mirrors of the projection lens, and the sensor frame 370, which substantially serves as a reference for the position of the mirrors of the projection lens, are illustrated roughly schematically. A shield 100 according to the invention is illustrated by way of example, said shield being mounted movably by way of a flexure 102. In addition, an actuator 122 is illustrated schematically, which serves for driving the movable shield 100 from a rest position into a functional position and back again. Figure 10a accordingly shows the movable shield 100 in the rest position. The EUV light source 301 is switched on. The microlithographic projection exposure apparatus 300 is shown in operation here.

Figure 11b shows a schematic illustration of a microlithographic projection exposure apparatus 300 according to the invention for the EUV range with a movable shield 100 having been folded in, in the functional position. The shield 100 shields only one mirror 355 purely by way of

example in Figure 11b. It is also possible, however, for a plurality or all of the mirrors 352 to 355 to be shielded respectively by a movable shield 100. The EUV light source 301 is switched off. The microlithographic projection exposure apparatus 300 is at least partly opened (not illustrated in Figure 11b) for maintenance purposes.

Figure 12a shows a schematic illustration of a microlithographic projection exposure apparatus according to the invention for the DUV range 400 with a foldable movable shield 100 in the rest position. The DUV projection exposure apparatus 400 comprises a beam shaping and illumination device 402 and a projection lens 404. In this case, DUV stands for “deep ultraviolet” and denotes a wavelength of the working light of between 30 and 250 nm. The DUV projection exposure apparatus 400 comprises a DUV light source 406. By way of example, an ArF excimer laser that emits radiation 408 in the DUV range at 193 nm, for example, can be provided as the DUV light source 406.

The beam shaping and illumination device 402 illustrated in Fig. 12a guides the DUV radiation 408 onto a photomask 420. The photomask 420 is embodied as a transmissive optical element and can be arranged outside the beam shaping and illumination device 402 and the projection lens 404. The photomask 420 has a structure which is imaged onto a wafer 424 or the like in a reduced fashion by means of the projection lens 404.

The projection lens 404 has a plurality of lens elements 428, 440 and/or mirrors 430 for imaging the photomask 420 onto the wafer 424. In this case, individual lens elements 428, 440 and/or mirrors 430 of the projection lens 404 can be arranged symmetrically in relation to the optical axis 426 of the projection lens 404. It should be noted that the number of lens elements and mirrors of the DUV projection exposure apparatus 400 is not restricted to the number illustrated. More or fewer lens elements and/or mirrors can also be provided. Furthermore, the mirrors are generally curved on their front side for beam shaping.

An air gap between the last lens element 440 and the wafer 424 can be replaced by a liquid medium 432 which has a refractive index of > 1 . The liquid medium 432 can be high-purity water, for example. Such a construction is also referred to as immersion lithography and has an increased photolithographic resolution.

In Fig. 12b, the movable shield 100 according to the invention is illustrated in the functional position, that is to say in the folded-in state, and thermally shields one of the two mirrors 430, for example. A flexure 102 and an actuator 122 are illustrated schematically here as well. The illustrated microlithographic projection exposure apparatus for the DUV range 400 is in the rest state, that is to say for example when it has been at least partly opened for maintenance purposes.

Even though the invention has been described on the basis of specific embodiments, numerous variations and alternative embodiments will be apparent to the person skilled in the art, for example through combination and/or exchange of features of individual embodiments.

Accordingly, it goes without saying for the person skilled in the art that such variations and alternative embodiments are also encompassed by the present invention, and the scope of the invention is restricted only within the meaning of the appended patent claims and the equivalents thereof.

List of reference signs

- 100 Movable shield
- 101 Infrared radiation-reflecting layer
- 102 Flexure
- 103 Piping on the surface of the movable shield
- 104 Additional temperature-regulating source
- 105 Heat accumulator
- 106 Temperature-regulating fluid and/or infrared radiation
- 107 Heating wires
- 108 Openings in the volume of the movable shield
- 109 Fluid
- 110 Component to be thermally insulated, in particular mirror
- 111 Rail
- 113 Infrared radiation-reflecting layer
- 114 Carrying structure
- 119 Temperature-regulating medium
- 122 Actuator
- 130 Positioning direction of the cover
- 140 Pivoting direction of the cover
- 210 Component to be thermally insulated, in particular mount technology element
- 300 EUV projection exposure apparatus (= EUV system)
- 301 to 360 Parts of the EUV projection exposure apparatus
- 370 Sensor frame
- 380 Force frame
- 400 DUV projection exposure apparatus (= DUV system)
- 402 to 440 Parts of the DUV projection exposure apparatus

Patent claims:

1. Microlithographic projection exposure apparatus, in particular for the DUV range (400) or for the EUV range (300), comprising at least one movable shield (100) and at least one component (110, 210) to be thermally insulated, wherein the at least one movable shield (100) is configured, in an operating pause of the microlithographic projection exposure apparatus (300, 400), for example in the case of maintenance, to lengthen the time duration in which the temperature of the at least one component (110, 210) to be thermally insulated approaches the ambient temperature.
2. Microlithographic projection exposure apparatus according to Claim 1, wherein the component (110) to be thermally insulated comprises at least one mirror, in particular designed for reflecting electromagnetic radiation from the EUV range.
3. Microlithographic projection exposure apparatus according to Claim 1 or 2, wherein the component (210) to be thermally insulated comprises at least one mount technology element.
4. Microlithographic projection exposure apparatus according to any of the preceding claims, wherein the material of the movable shield (100) comprises at least one thermal insulator, preferably:
 - PTFE,
 - POM,
 - silicate ceramic.
5. Microlithographic projection exposure apparatus according to any of the preceding claims, wherein the movable shield (100), on its side facing the component (110, 210) to be thermally insulated, is provided with at least one coating (101) that is at least partly reflective to electromagnetic radiation in the infrared range.
6. Microlithographic projection exposure apparatus according to any of the preceding claims, wherein the movable shield (100), on its side facing away from the component (110, 210) to be thermally insulated, is provided with at least one coating (113) that is at least partly reflective to electromagnetic radiation in the infrared range.

7. Microlithographic projection exposure apparatus according to any of the preceding claims, wherein the movable shield (100) encloses the component (110, 210) to be thermally insulated at least regionally and/or at least at times in the operating pause of the microlithographic projection exposure apparatus.

8. Microlithographic projection exposure apparatus according to any of the preceding claims, wherein the movable shield (100) is spaced apart from the component (110, 210) to be thermally insulated at a distance of between 1 mm and 20 mm, preferably at a distance of between 2 mm and 5 mm, in the operating pause of the microlithographic projection exposure apparatus.

9. Microlithographic projection exposure apparatus according to any of the preceding claims, wherein the movable shield (100) has at least one cavity (108) filled with a fluid (109), preferably with air.

10. Microlithographic projection exposure apparatus according to any of the preceding claims, wherein the movable shield (100) is temperature-regulatable, preferably by at least one of the following measures:

- contact with a heat accumulator (105),
- temperature-regulating medium (119) flow in the volume of the movable shield (100),
- temperature-regulating medium (119) flow in piping (103), which is soldered on, in particular, on the surface of the movable shield (100),
- electrical heating by electrical resistance wires (107) in and/or on the movable shield (100).

11. Microlithographic projection exposure apparatus according to any of the preceding claims, wherein in the operating pause of the microlithographic projection exposure apparatus, in particular at the beginning of the operating pause, the movable shield (100), in particular by means of at least one actuator (122), is slidable and/or foldable from a rest position in the direction of the component (110, 210) to be thermally insulated into a functional position.

12. Microlithographic projection exposure apparatus according to any of the preceding claims, wherein the movable shield (100) comprises at least one flexure (102), in particular a rotary joint, and/or a leg spring.

13. Microlithographic projection exposure apparatus according to any of the preceding claims, wherein the movable shield (100) comprises at least one guide arranged outside an optical used region, for example in the form of at least one guide rail (111).

14. Microlithographic projection exposure apparatus according to any of the preceding claims, comprising at least one temperature-regulating source (104), in particular at least one infrared (106) radiator, wherein the temperature-regulating source (104) regulates the temperature of the region between the movable shield (100) and the component (110, 210) to be insulated.

15. Method for thermally insulating at least one component of a microlithographic projection exposure apparatus, comprising at least the following steps:

- switching off or shading at least one light source (301, 406) in an operating pause of the microlithographic projection exposure apparatus,
- moving at least one movable shield (100) from a rest position into a functional position in such a way that in the functional position the component (110, 210) to be thermally insulated is enclosed at least regionally by the movable shield (100).

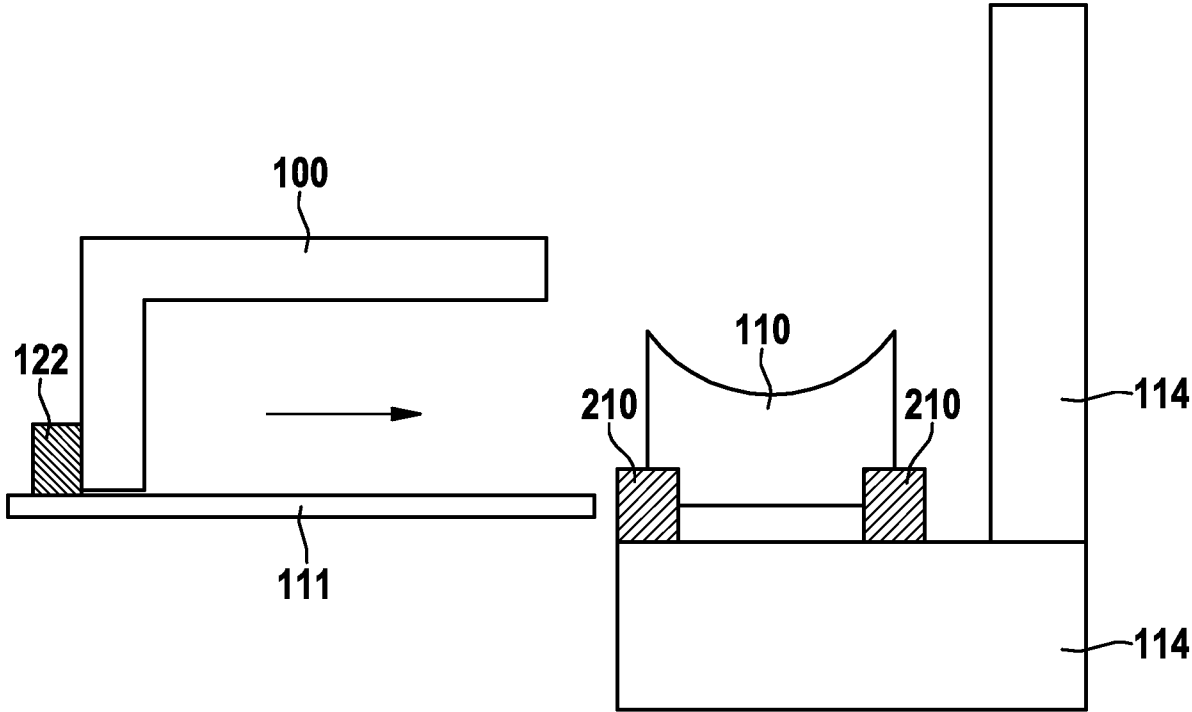


Fig. 1a

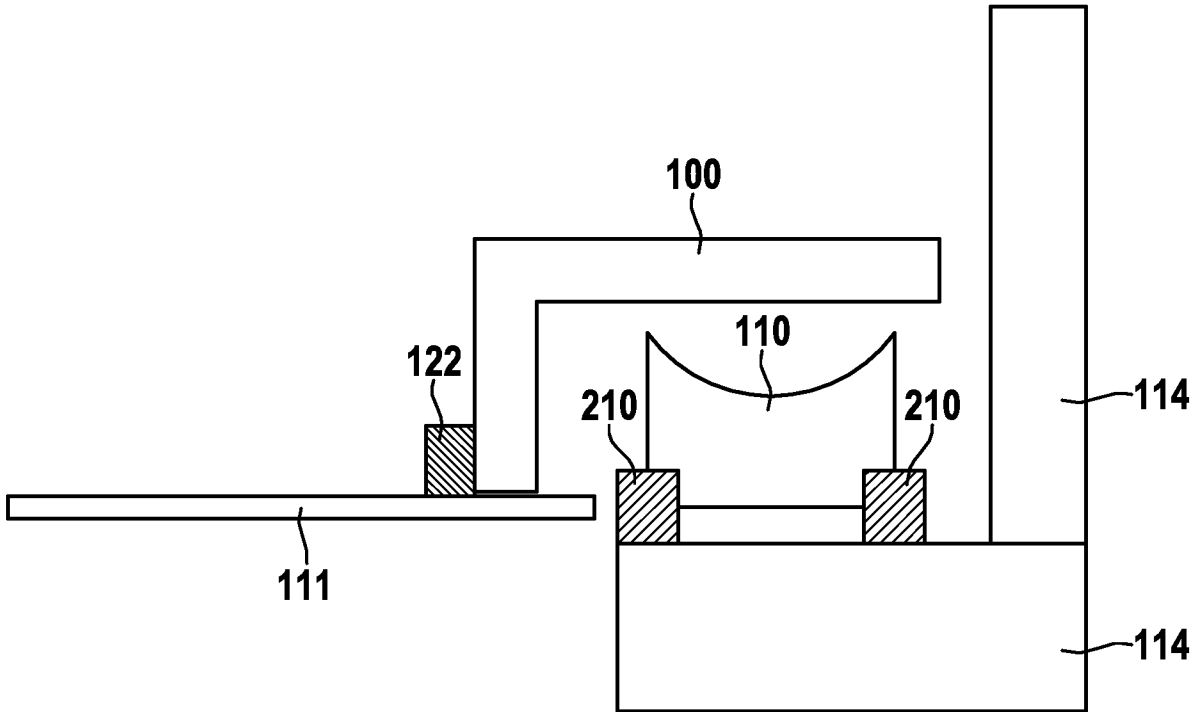


Fig. 1b

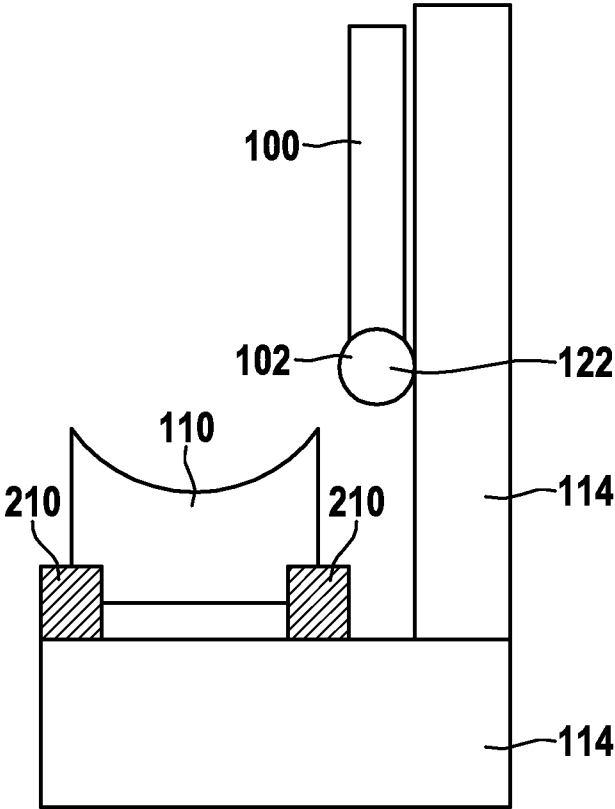


Fig. 2a

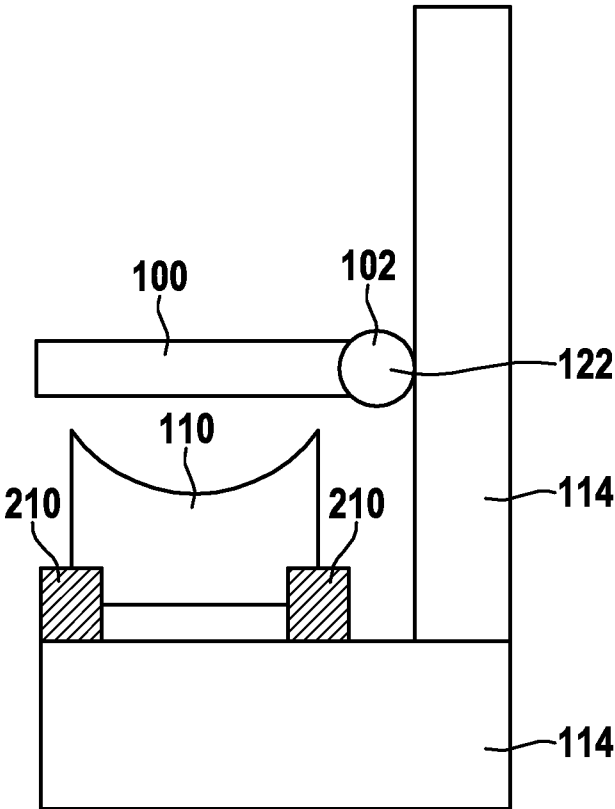


Fig. 2b

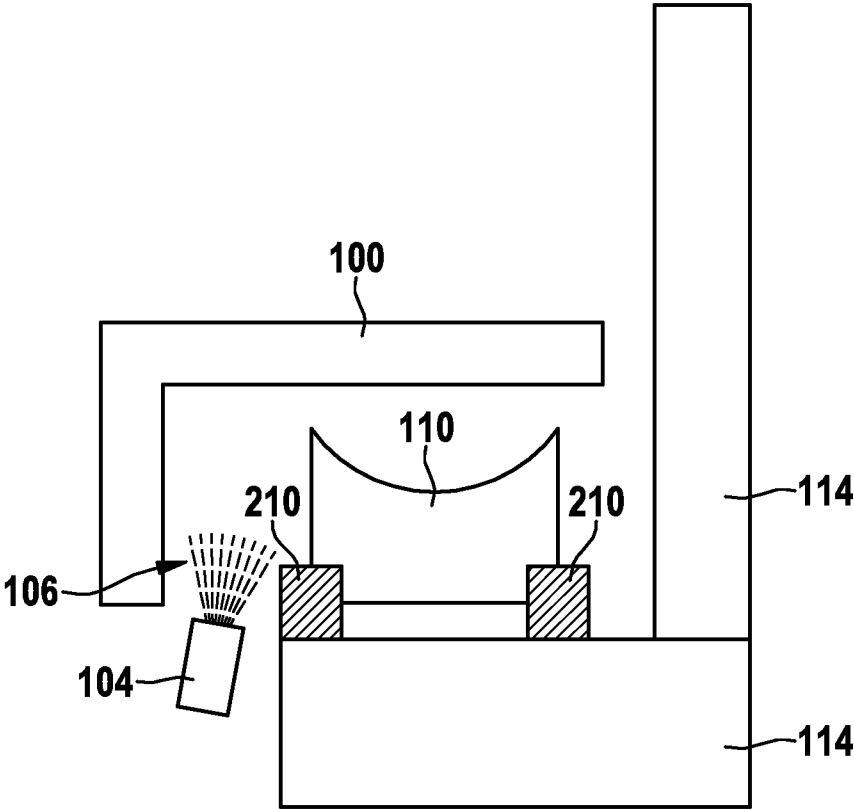


Fig. 3

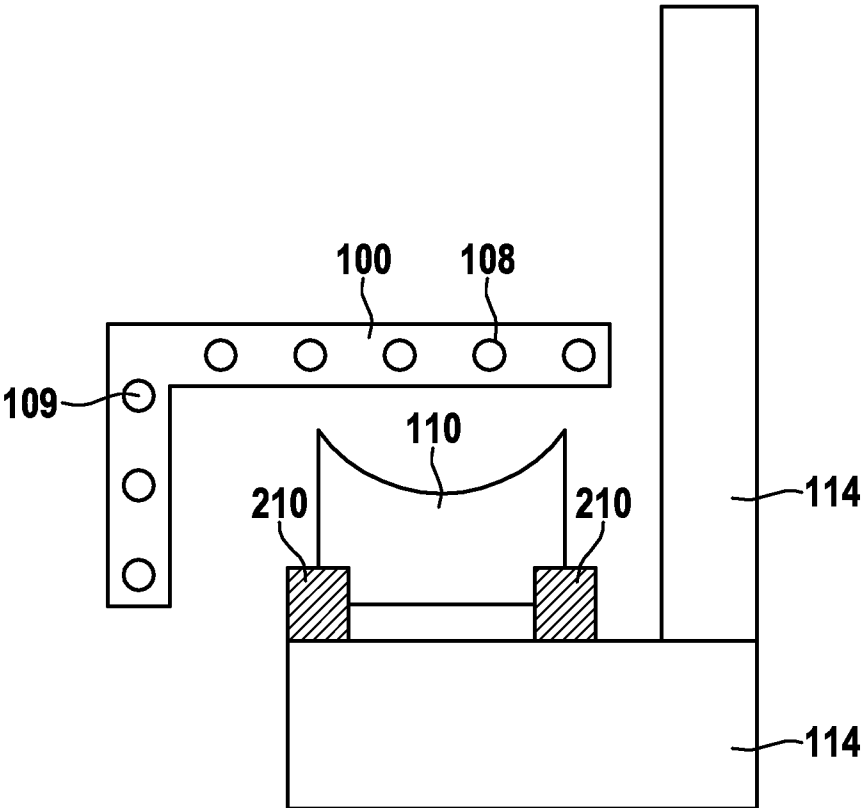


Fig. 4

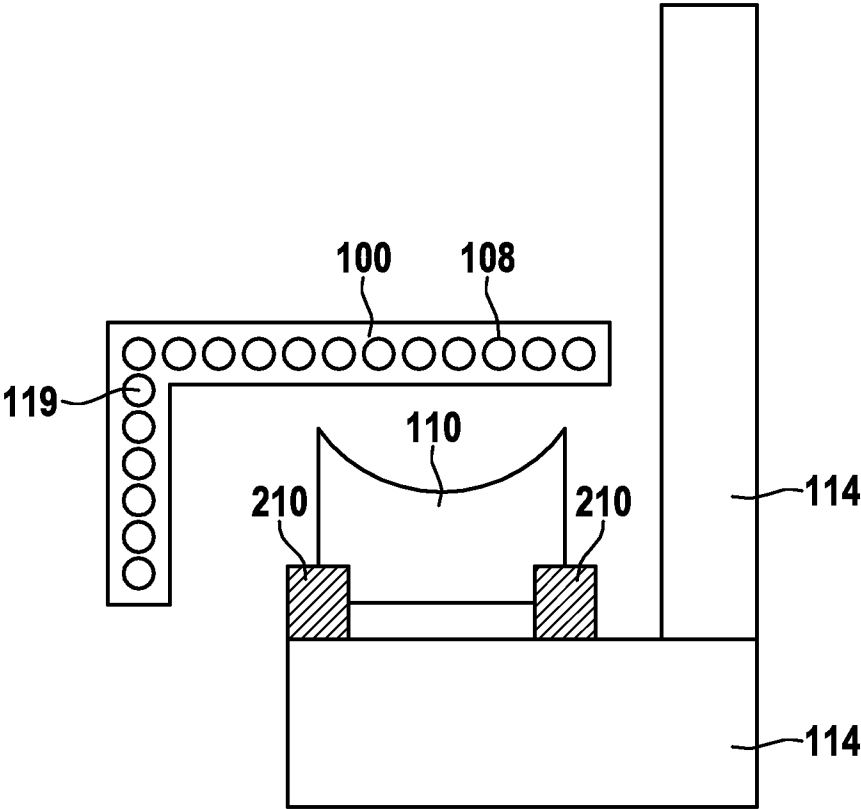


Fig. 5

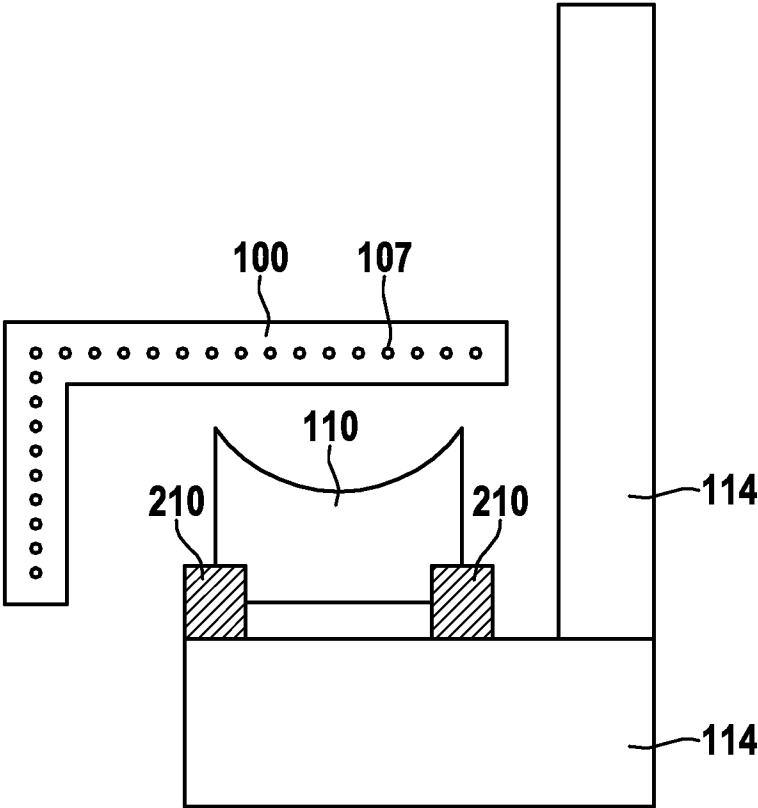


Fig. 6

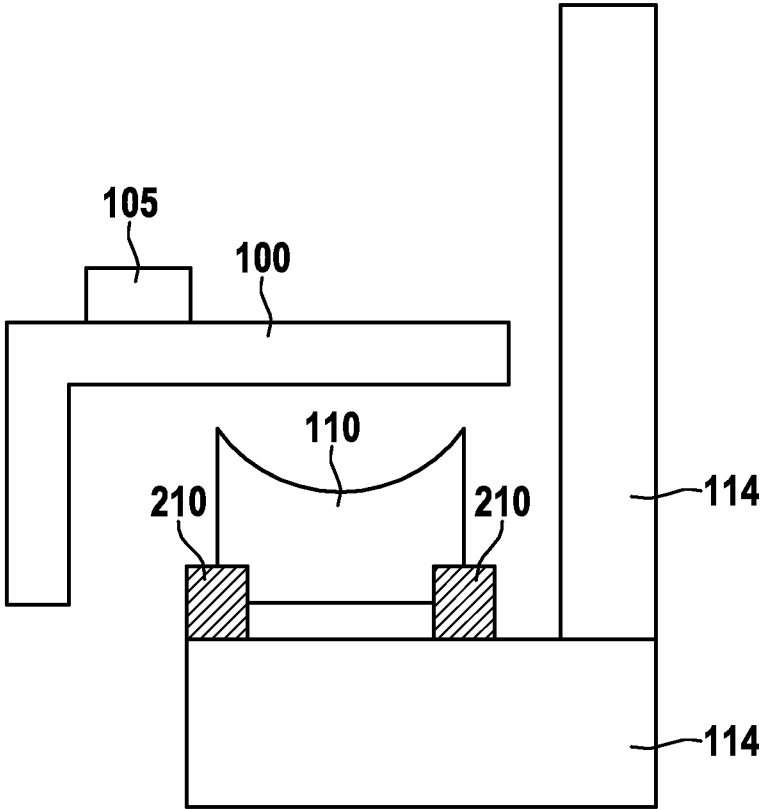


Fig. 7

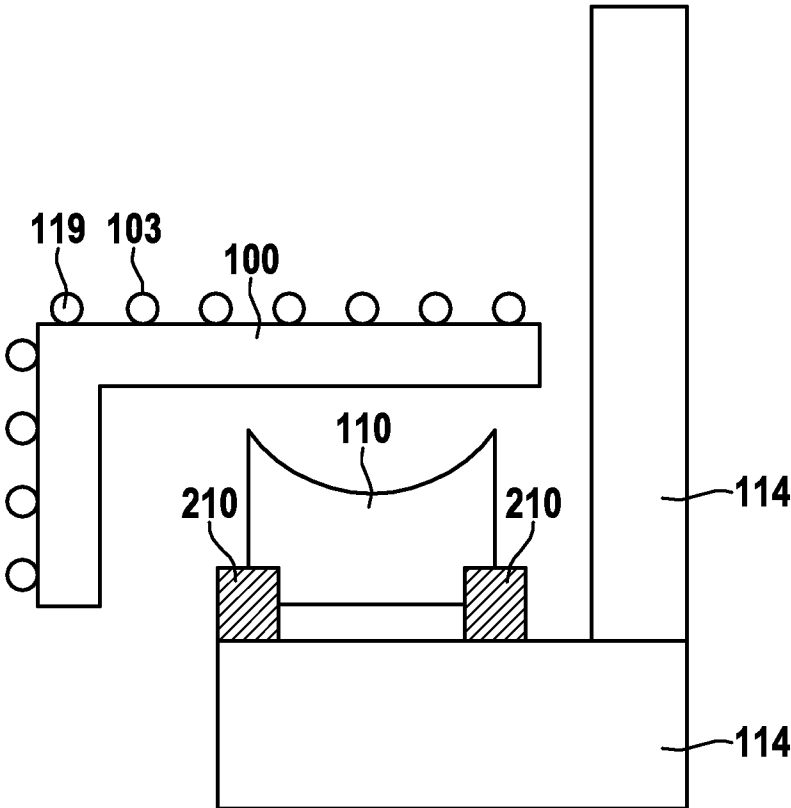


Fig. 8

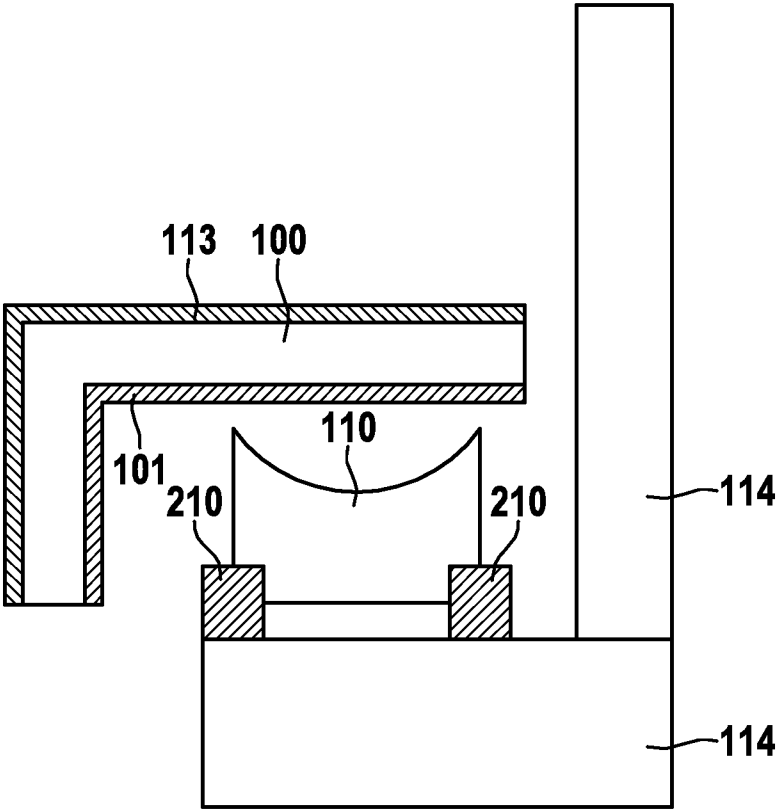


Fig. 9

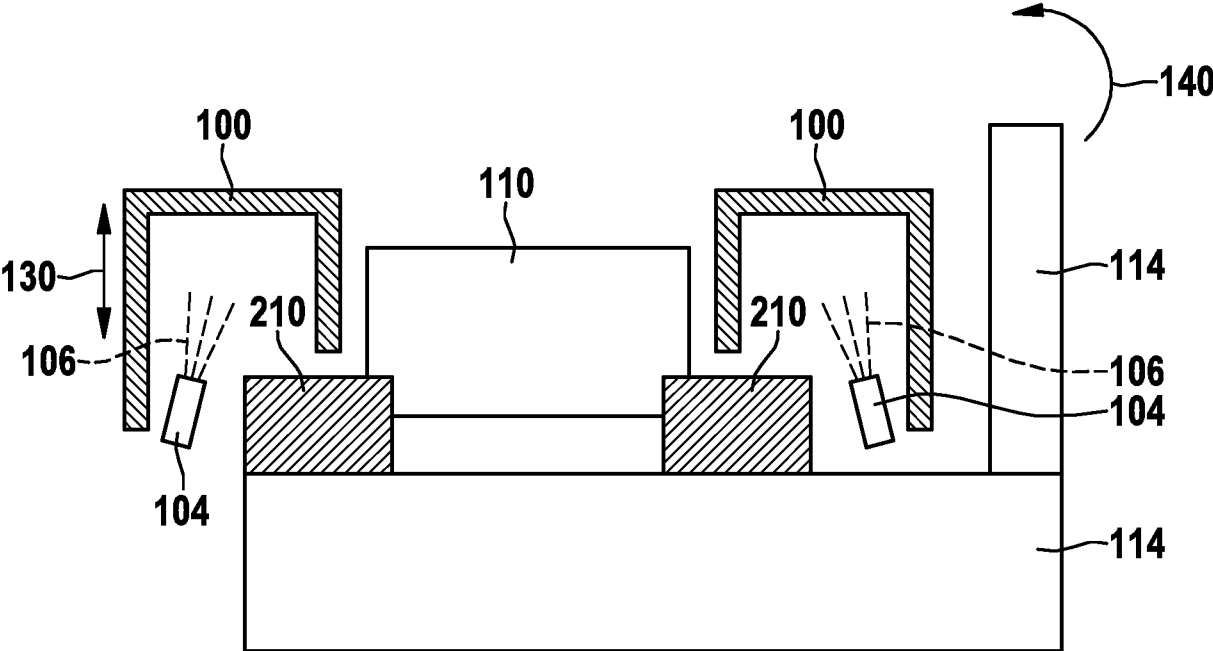


Fig. 10a

7 / 11

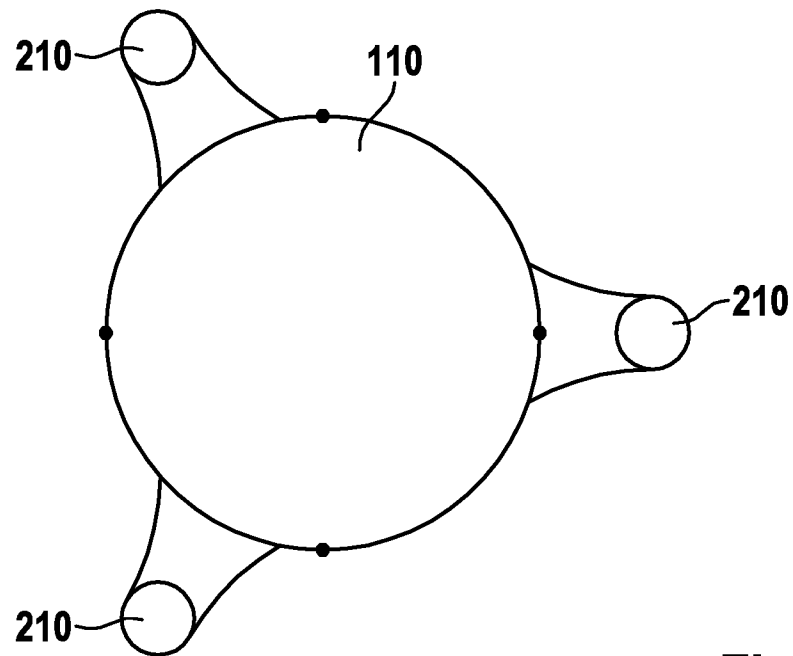


Fig. 10b

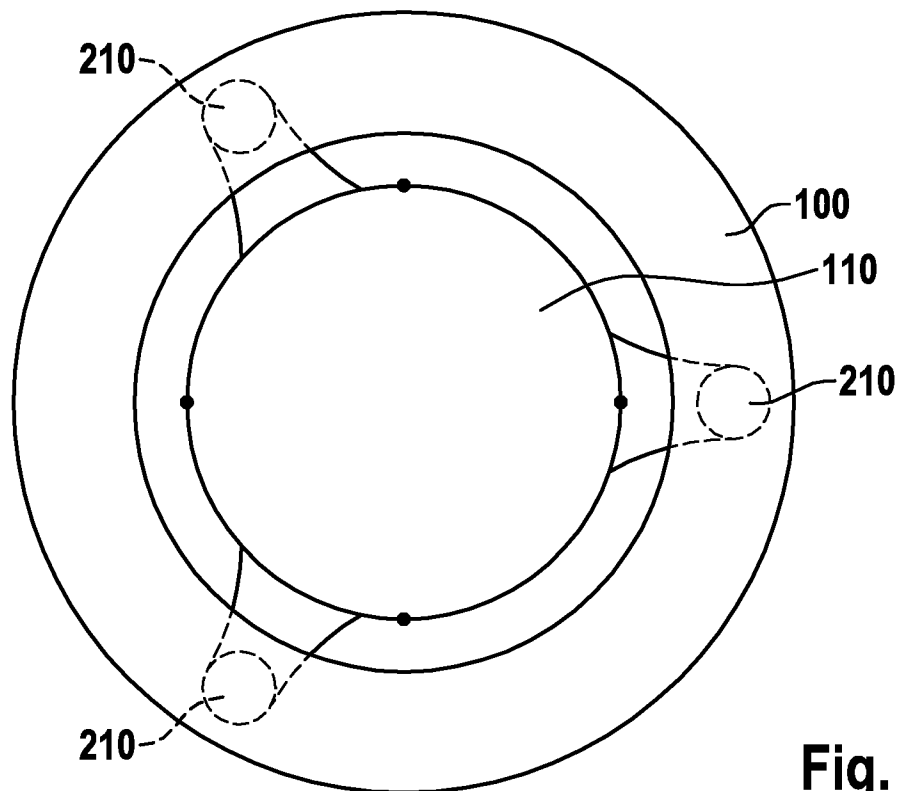


Fig. 10c

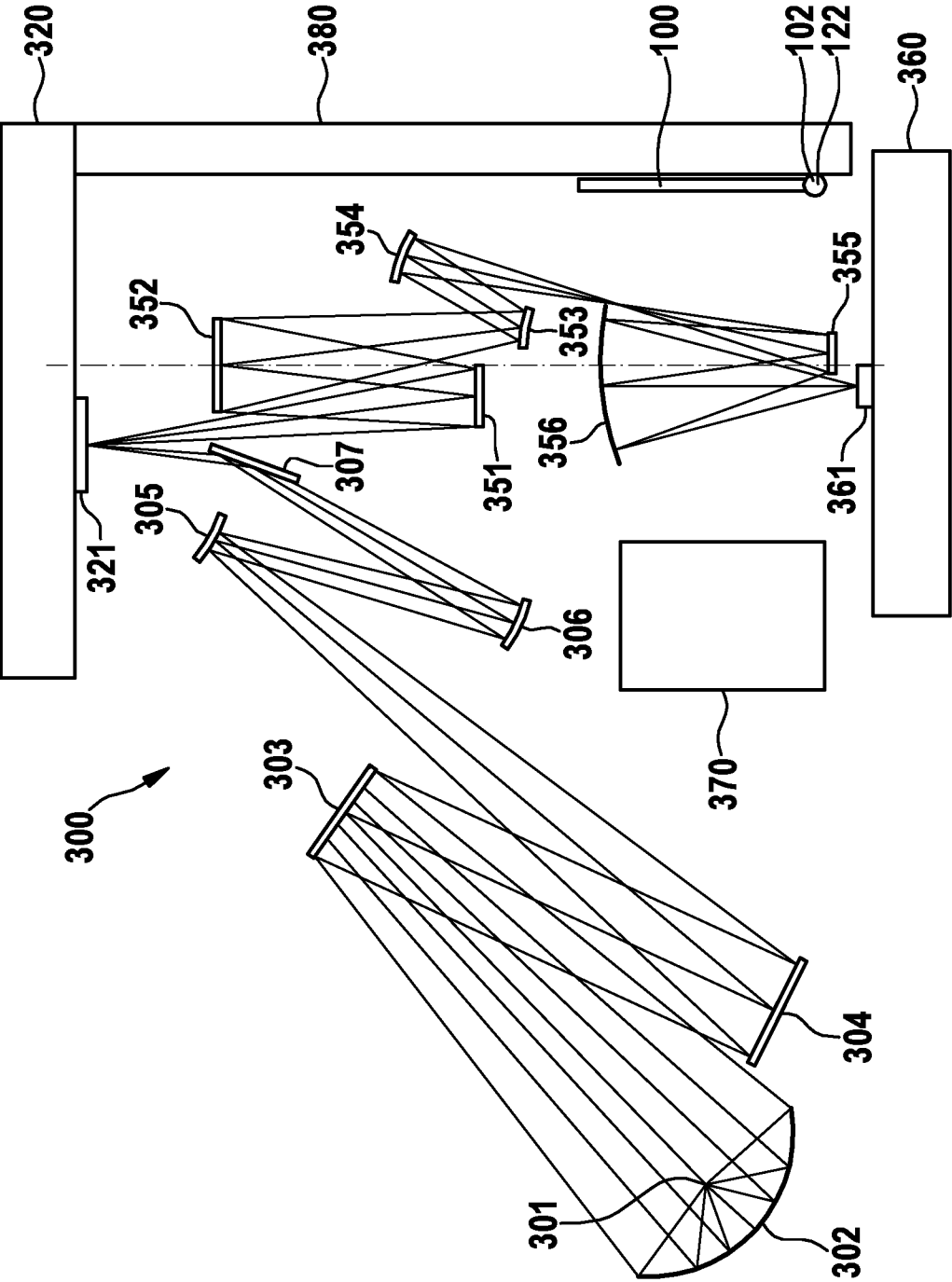
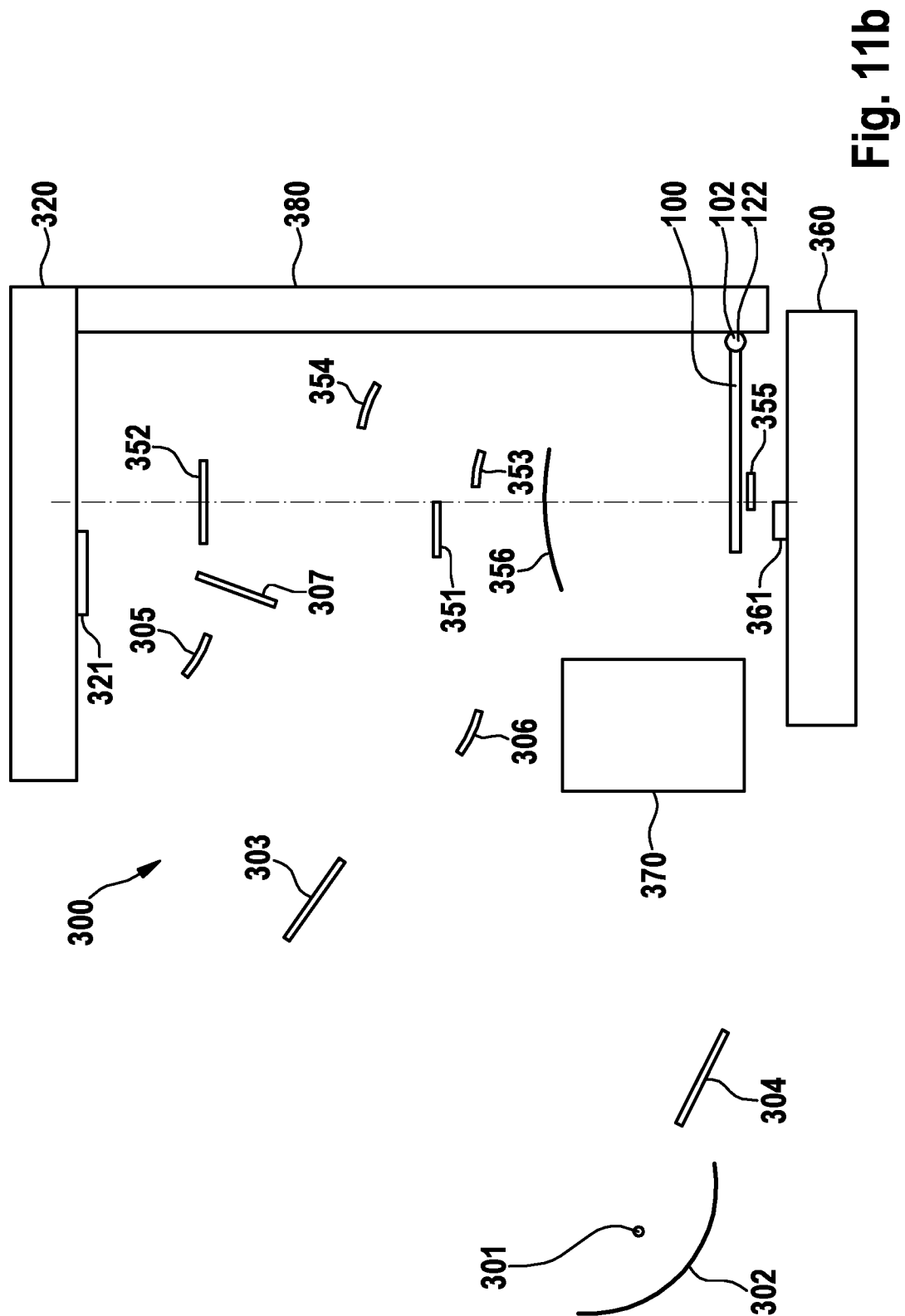


Fig. 11a



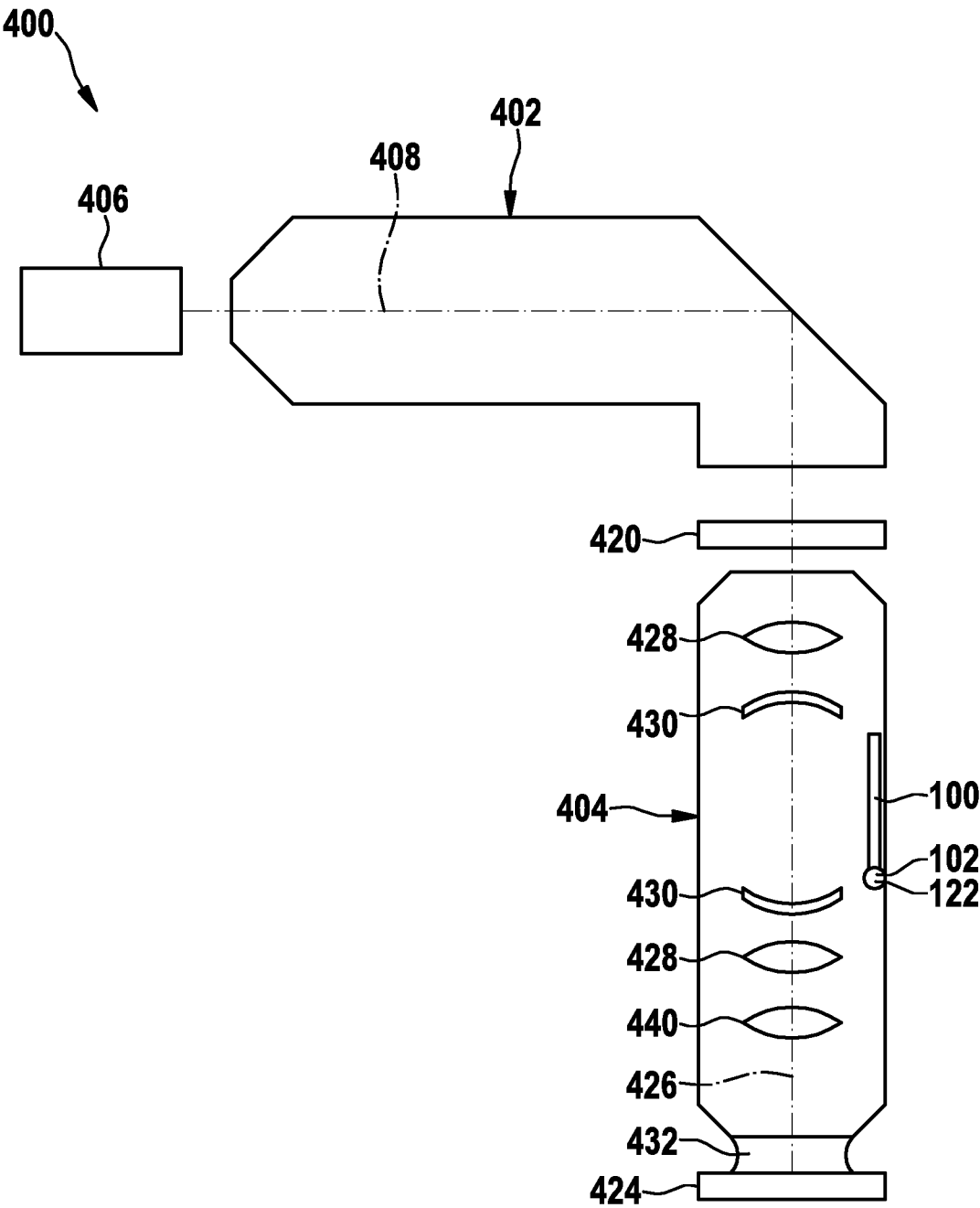


Fig. 12a

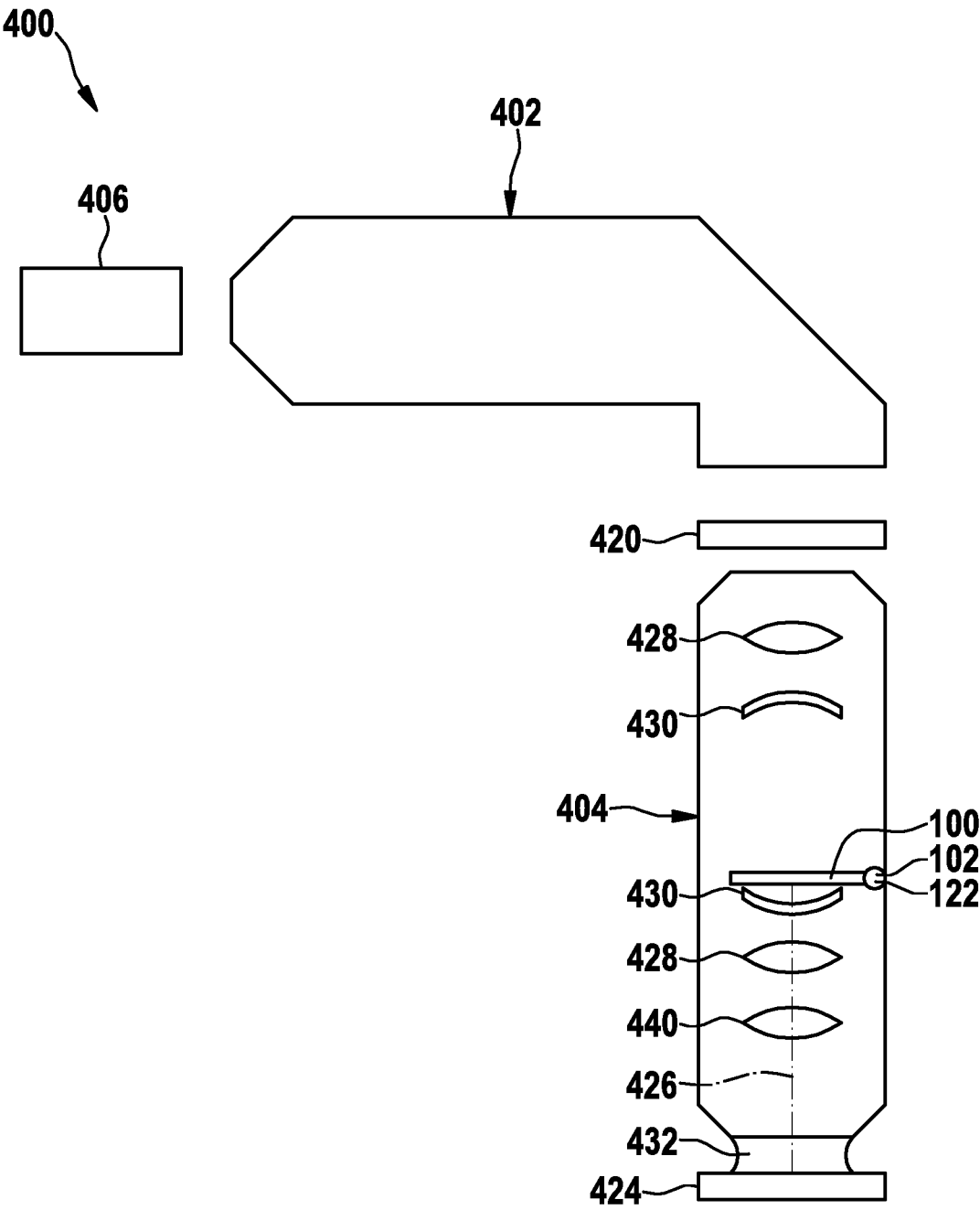


Fig. 12b

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/073741

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

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

B. FIELDS SEARCHED

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

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 practicable, search terms used)

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

24 November 2020

Date of mailing of the international search report

03/12/2020

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van Toledo, Wiebo

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/073741

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