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(71) Applicant: APPLIED MATERIALS, INC. [US/US];

3050 Bowers Avenue, Santa Clara, California 95054 (US).

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(72) Inventor: MARKLE, David; 3528 Streamside Circle,

Pleasanton, California 94588 (US).

(74) Agent: PATTERSON, B. Todd et al.; PATTERSON +

SHERIDAN, LLP, 24 Greenway Plaza, Suite 1600, Houston, Texas 77046 (US).

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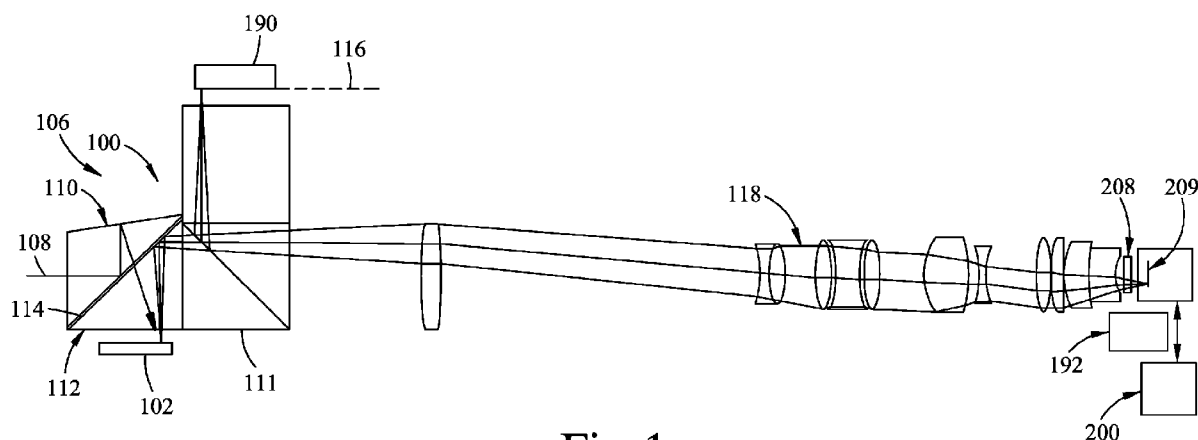


Fig. 1

(57) Abstract: A method to test a projection system is disclosed, which projects an illuminated pattern through an imaging system having a pupil plane and an image plane and, which has a camera focused on the image plane. A separate optical system is aligned with the projection system, which reverses the direction of the projected light and images the pupil onto the image plane thereby providing an image of the pupil plane to the camera.

PUPIL VIEWING WITH IMAGE PROJECTION SYSTEMS

BACKGROUND

Field

[0001] Aspects of the disclosure relate to image projection systems. More specifically, aspects relate to systems and methods for viewing of images of a pupil plane of an image projection system.

Description of the Related Art

[0002] Optical systems often have problems related to proper imaging. The correct diagnosis of optical system problems sometimes depends on obtaining a view of the light distribution that occurs in the pupil of the imaging system which can strongly affect the results of the imaging. This is particularly true if the object being viewed has a periodic structure and the illumination system is somewhat coherent.

[0003] Projection systems can vary in size and content of the components used. An example lithographic projection system may have a Texas Instruments Digital Light Projector (DLP) chip wherein a number of laser diodes emitting in the 405 nm spectral region are used to illuminate the DLP. In a 1080p model of this DLP, there are approximately 2 million mirrors, arranged on a rectangular lattice with a 10.6 μm spacing between adjacent mirrors. The regular spacing between the mirrors combined with the narrow spectral bandwidth of the laser diodes leads to an energy distribution in the pupil that depends upon the pattern of “on” mirrors as well as the incident angle of the illumination and wavelength. For purposes of definition, a mirror that is “on” is a mirror that has a reflection that passes through the projection system, while a mirror that is “off” produces a reflection that does not pass through the projection system. As will be understood by a person of skill in the art, the mirrors may rotate approximately ± 12 degrees from the “off” to the “on” position in example types of projection systems.

[0004] Generally, lithography projection systems are designed to very exacting standards. The systems, while they may vary, are usually telecentric in both the object and image spaces, so that changes in the axial position of the object or image planes do not change a desired magnification ratio. In such a system, and

neglecting diffraction effects, a cone of reflected illumination from each of the “on” mirrors is normal to an object plane. This ensures that the pupil of the projection system is symmetrically illuminated and the incident light is normal (90 degrees) to the substrate being exposed. If the grating nature of the DLP chip creates an unsymmetrical distribution in the pupil, then the magnification will vary with focus position and the resultant overlay and alignment accuracy will suffer a loss of accuracy.

[0005] It is desired, therefore, to ensure that the illumination across a digital lithography system pupil be as centered as possible. To ensure proper illumination, optical systems may be added to conventional imaging systems to perform a measurement of the light distribution at the pupil. Adding an optical system that will view the illumination distribution in the pupil, in a conventional manner however, has many drawbacks. Adding a separate optical system to view the illumination profile in the pupil is expensive and requires a relatively large amount of space in an area where space is scarce. Such an added optical system also has the drawback of requiring a separate camera to record and display the image of the pupil. Generally, performing such a function requires the addition of a beam-splitter or a flip mirror located between the pupil stop and the image plane to extract the pupil image as well as a fairly complex imaging system to image the pupil onto the added camera. Light reflected from the extra optical elements, including the beam-splitter and camera can contribute stray light to the projected image, thereby generating faint, but objectionable image imperfections.

[0006] Such complexities and the cost associated with the designed systems have additional drawbacks. While a pupil imaging system is needed, it is only used sporadically for trouble-shooting. For example, a pupil imaging system would be used when a shock causes the projection system to misalign or when a particular pattern on the DMD, combined with the periodic arrangement of the DMD mirrors and the narrow spectral range of the illumination, fails to create the desired pattern on the substrate. Such a system might also be used to locate a component having a damaged coating or a degraded transmission caused by solarization.

[0007] Many projection systems contain a beam-splitter between an object plane and the pupil, wherein the beam-splitter is used to reimage the projected image onto

a camera along with the pre-existing patterns on the substrate onto which the image was projected. The camera image can then be used to align the projected image with the pre-existing patterns.

[0008] There is a need to provide a method for imaging the pupil onto the image plane, which may be imaged back onto the camera used for alignment, alleviating the need for an extra camera, a beam-splitter, and an extra optical system.

[0009] There is a further need to provide a cost effective system that will allow a pupil to be evaluated during operational conditions that allows operators to quickly check a digital lithography system for optimum performance.

[0010] There is also a still further need to provide a cost effective system that will be easily removable or movable to provide for evaluation of pupil illumination effects so that processing up-time is not compromised by the time taken to perform checks or calibrations of the machine components.

SUMMARY

[0011] A non-limiting summary is presented. This summary is not to be considered limiting of the embodiments that are possible as seen through the detailed description provided below.

[0012] In one non-limiting embodiment, a method for testing is disclosed comprising patterning an illumination beam from a light source passing the patterned beam through at least one imaging system, the imaging system having a pupil plane, the patterned beam passing through the pupil plane a first instance, reflecting the patterned beam off an arrangement that switches the pupil and image plane positions and reverses the direction of the beam so that the patterned beam passes back through the imaging system pupil in a second instance to a camera wherein the pupil plane is imaged at the camera.

[0013] In another non-limiting embodiment, a device is disclosed comprising at least one optical element having a first refractive surface and a second reflective surface configured to be placed near an image plane, the at least one optical element configured to reverse a direction of light traveling through an imaging system and image a pupil onto an image plane and a mounting system configured to

support the at least one optical element to a projection system, wherein the mounting system allows for the at least one optical element to be moved from a first active position in the image plane to a second inactive position away from the image plane.

[0014] In another non-limiting embodiment, a device is provided comprising at least one optical element having a first convex surface and a second convex surface configured to be placed near an image plane of an imaging system, the at least one optical element configured to reverse a direction of light traveling through the imaging system and image a pupil of the imaging system onto an image plane, wherein the second convex surface is configured with a reflective coating; a mounting system configured to support the at least one optical element to a projection system, wherein the mounting system allows for the at least one optical element to be moved from a first active position in the image plane to a second inactive position away from the image plane and at least one motor configured to move the mounting system from the first active position to the second inactive position.

[0015] In another non-limiting embodiment, a device is disclosed comprising at least one optical element having a reflective surface configured to be placed near an image plane of an imaging system, the at least one optical element configured to reverse a direction of light traveling through the imaging system and image a pupil of a projection system onto an image plane and a kinematic mounting arrangement configured to position the at least one optical element with respect to the projection system.

[0016] In another non-limiting embodiment, a method to test a projection system, is disclosed comprising illuminating one of an image transducer and a mask containing a pattern with an illumination beam, passing the patterned illumination beam through at least one imaging system, the imaging system having a pupil plane, the light beam passing through the pupil plane a first instance, moving a lens arrangement into the light beam that has passed through the pupil, which switches the image and pupil plane positions and reflects the light beam so it passes through the pupil in a second instance to image the pupil plane at a camera and analyzing the light beam received at the camera.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] So that the manner in which the above recited features of the present disclosure can be understood in detail, a more particular description of the disclosure, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only exemplary embodiments and are therefore not to be considered limiting of its scope, and may admit to other equally effective embodiments.

[0018] FIG. 1 is a cross-section of a lithographic projection system having a 3:1 reduction ratio, which also shows the position of the optical system that permits pupil viewing.

[0019] FIG. 2 is a cross-section of a pupil imaging system with incoming rays.

[0020] FIG. 3 is a cross-section of the pupil imaging system of FIG. 1 with outgoing rays.

[0021] FIG. 4 is a flow chart providing a method for pupil viewing of a digital lithography system.

[0022] To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures. It is contemplated that elements disclosed in one embodiment may be beneficially utilized on other embodiments without specific recitation.

DETAILED DESCRIPTION

[0023] In the following description, reference is made to embodiments of the disclosure. It should be understood, however, that the disclosure is not limited to specific described embodiments. Instead, any combination of the following features and elements, whether related to different embodiments or not, is contemplated to implement and practice the disclosure. Furthermore, although embodiments of the disclosure may achieve advantages over other possible solutions and/or over the prior art, whether or not a particular advantage is achieved by a given embodiment is not limiting of the disclosure. Thus, the following aspects, features, embodiments and advantages are merely illustrative and are not considered elements or

limitations of the appended claims except where explicitly recited in a claim. Likewise, reference to “the disclosure” shall not be construed as a generalization of an inventive subject matter disclosed herein and shall not be considered to be an element or limitation of the appended claims except where explicitly recited in a claim.

[0024] Some embodiments will now be described with reference to the figures. Like elements in the various figures will be referenced with like numbers for consistency. In the following description, numerous details are set forth to provide an understanding of various embodiments and/or features. It will be understood, however, by those skilled in the art that some embodiments may be practiced without many of these details and that numerous variations or modifications from the described embodiments are possible. As used herein, the terms “above” and “below”, “up” and “down”, “upper” and “lower”, “upwardly” and “downwardly”, and other like terms indicating relative positions above or below a given point or element are used in this description to more clearly describe certain embodiments.

[0025] The embodiments disclosed provide an arrangement that allows a user to diagnose optical system problems by viewing the illumination distribution at the projection system pupil plane. A lens provided with a reflective coating on one surface, or a convex mirror, may be used to enable imaging of the pupil plane along with existing components provided within a projection system. The optical system used for such diagnostic capabilities may be a movable arrangement that may be motorized and computer controlled if desired. Such an arrangement alleviates the need to provide a separate configuration of beam-splitters, optical relays, and cameras to perform such diagnosis. Different types of optical system arrangements may be provided to allow analysis of illumination of the pupil. The pupil image may be received by a camera and subsequently analyzed as needed. Such analysis may be accomplished by taking the image received by the camera and comparing the image to a reference image. In another example embodiment, the camera image may be analyzed for symmetry.

[0026] Photolithography is widely used in the manufacturing of semiconductor devices and display devices. Such devices may include, for example, liquid crystal displays. To create these displays, substrates must be prepared and processed in a

number of steps to allow the display to function as intended. These displays can vary in size from small LCD screens used on portable consumer electronics products, to large flat panel displays that are used in large televisions, as well as computers, personal digital assistants, cell phones and similar electronics.

[0027] Flat panels can be constructed in several configurations. One such configuration includes a layer of liquid crystal material forming pixels sandwiched between two plates. When an electric field is applied across the liquid crystal material, the amount of light passing through the liquid crystal material can be controlled. By choosing which pixels pass light and which are opaque, images can be generated on the display.

[0028] Microlithography processes are used to create electrical features incorporated as part of the liquid crystal material layer forming the pixels. In microlithography, a light-sensitive material called "photoresist" is applied in an even coating over the surface of a substrate containing a layer of material that needs to be patterned. After curing, the substrate with the layer of photoresist is exposed to a patterned light source which causes chemical changes in the parts of the photoresist layer exposed to the light. Subsequent immersion of the substrate in a developer selectively removes either the exposed or unexposed parts of the resist layer, depending on whether the resist is positive or negative acting. This is generally followed by an etch step, which removes any of the underlying material, which is unprotected by the resist coating. At this point the remaining resist is removed, another layer is added followed by a resist layer and the process is repeated.

[0029] As should be apparent, very fine details to be created on a layer of photoresist are necessarily made by short-wavelength light. Longer wavelengths provide less resolution in the layer of photoresist. Wavelengths of less than 408 nm are used in most digital lithography systems. Additionally, certain types of photoresist react more strongly to specific wavelengths, therefore the spectrum of the light source employed in a lithographic imaging system is best matched to the sensitivity spectrum of the photoresist used.

[0030] In an effort to produce these ever finer details with lithographic techniques, maintaining the complex lithographic systems at an optimum performance level is increasingly important.

[0031] FIG. 1 is a cross-section through a 3:1 lithographic projection system **100** used to project an image of a Texas Instrument DLP **102** onto a photoresist coated substrate. The DLP **102** is a digital micro-mirror device (DMD) which controls an array of small mirrors for projecting the necessary light. The mirror array may be connected to a heat sink, to remove excess heat generated at the mirror face. The DLP **102** may be a single chip or a multiple chip unit, as necessary.

[0032] A frustrated cube **106** located adjacent to the DLP **102** is used to efficiently illuminate the DLP **102** with an off-axis illumination beam **108** and to direct the illumination reflected from the “on” mirrors in the DLP **102** down the axis of the projection system through a lens system. The lens system can include, for example, lenses with configurations that are biconvex, plano-convex, positive meniscus, plano-concave, biconcave and negative meniscus, as non-limiting example embodiments.

[0033] A specific system consists of a first 45 degree prism **110**, a second 45 degree prism **112**, and a gap **114** that separates the prisms. The first 45 degree prism **110** and second 45 degree prism **112** transmits an off-axis illumination beam **108** onto the DLP surface. On mirrors on the DLP change the off-axis angle to on-axis and this component of the beam then passes down the projection system axis. The cross-section provided in FIG.1 duplicates the path between the DLP **102** and the projection system **100**. A 45 degree beam-splitter **111** collects some of the energy reflected from the substrate **104** and images the energy on a camera focal plane **116** that is conjugate with the DLP focal plane.

[0034] The pupil **118** has a position as shown in FIG. 1. When viewed from either the object or image space, the pupil **118** appears to be located at infinity, which is a direct consequence of the telecentricity requirement. Thus, the center ray of each beam imaging a DLP pixel is normal to the object and image planes, neglecting grating effects generated by the regular spacing the DLP mirrors. An optical component **200** is placed at the end of the imaging system to conduct the desired testing of the projection system **100**. The optical component **200** may be placed on a mounting system **201** [Not currently in Fig. 1] that is able to move the component from a first “active” position to a second “inactive” position. In the first “active position” the component **200** is properly aligned to reflect a light beam back

at the camera **190** so that the light beam may go through the pupil **118** and eventually be detected by a camera **190**. A motor **192** may be connected to the optical component **200** to move the component into proper alignment. The motor **192** may be activated through use of a computer as necessary.

[0035] Referring to FIG. 2, the component **200** is inserted between the last optical element in the projection system **100**, which is a window **208**, and the image plane **209** or slightly beyond the image plane. One of the many possible forms of component **200** is a glass element that contains two curved surfaces, the first curved surface **203** functions as a refractive lens and second curved surface **204** functions as a spherical mirror. The second curved surface **204** can be covered with high reflectivity coatings or films to produce spectral selectivity.

[0036] In another example embodiment, the component **200** may have a dielectric mirror positioned on a rear side of the component **200**. The dielectric mirror may be configured of a number of different strata that each have reflective properties for the anticipated reflective light. As a result, if a multi-emission-line light source is used, the component **200** may have a number of layers to reflect the emission-line colors necessary. In another embodiment, if a single emission-line source is used, then a minimal number of layers may be created on the rear of the component **200** to reflect the monochromatic light. In the instance of use of a dielectric mirror device, the light reflective capability can be greater than 99 percent. The first curved surface **203** may be configured with an anti-reflective (AR) coating that will prevent unintended reflections from reaching back to the camera **190**. Typical types of AR coatings that may be used include single-layer interference coatings, multi-layer interference coatings and index matching coatings. Although described as a coating, it will be apparent that thin films may also be used to perform such tasks as providing reflection suppression. In either case, however, the coating or film should be configured such that the component **200** has a heat tolerance according to the expected power absorption from the illumination source that is being used. Such illumination sources can be laser, soft x-ray, conventional light, or other appropriate illumination sources.

[0037] The component **200** receives light beams **206** from the projection system **100**. The first curved surface **203** is configured to shift the image plane slightly to the

right and the second curved surface **204**, the mirror surface, images the pupil **118** onto the shifted focal plane surface. After passing through the refractive surface (the first curved surface **203**), on the way back through the lens, the pupil **118** appears to be located at the original focal plane and is therefore imaged on the DLP **102** and alignment camera **190**. The alignment camera **190** may then be used for an additional purpose, that being for receiving the image of the pupil **118**. The component **200** may be configured from a variety of materials including glass materials of crown glass, barium crown glass, heavy flint glass, borosilicate and barium flint. The component **200** could also be made from plastic compounds.

[0038] The return path of the reflected light beam **301** through the pupil **118** imaging component is illustrated in FIG. 3. On the return path, after passing through the first curved surface **203**, the pupil **118** appears to be located at the original image plane of the projection system **100** and therefore is reimaged on the alignment camera **190** and the DLP **102**.

[0039] On the reverse path through the projection system **100**, the image plane becomes a pupil plane, the original pupil plane becomes an image plane and the object plane becomes an image of the pupil. Since the alignment camera **190** also images the original image plane, the image of the pupil is also displayed on the camera **190**.

[0040] The pupil imaging system (with component **200**) is only used sporadically, such as for testing. Such uses would be if the imaging system were to be misaligned or degraded after a large number of repeated uses. If the optical imaging system is suspected as being the source of the image defects, the component **200** could be attached to the imaging system with a kinematic mounting system **201** that eliminates the need for alignment and facilitates use.

[0041] Referring to FIG. 4, a method **400** for pupil viewing of a digital lithography system is presented. The method **400** entails illuminating an image transducer **403** with a light source at **402**. The image transducer can be a DLP system operating in reflection as described above. The patterned light beam then passes through an imaging system **404**. The number of lenses that the light beam passes through can vary according to the needs of the system. In the illustrated embodiment, an imaging system that reduces the object to 1/3 its size at the image plane is shown,

however other configurations are possible. In one alternative embodiment, the light passing through the lens is intercepted in the vicinity of the image plane where the aberrations are well corrected and where an image of the pupil can be conveyed back to the object and camera planes with good fidelity.

[0042] In this region either a concave mirror, or a combination thick-lens/mirror combination, or a more elaborate optical system can be used to reverse the direction of the light and interchange the positions of the image and pupil planes so that a reasonably good image of the pupil is obtained at the camera component **200**. The component **200**, which performs the reversal and interchange, may be positioned using a motor that is computer controlled at **406**. The component **200**, described as a concave mirror or alternative embodiment above, is configured to reflect incident light **408** so this light travels back through the pupil **118** wherein the camera, at **110** receives the pupil image and the pupil image can be analyzed at **412**. There are many possible optical designs for component **200**, with the choice depending on the quality needed for the image of the pupil and the design of the projection system.

[0043] Although the projection system described above employs a 3:1 reduction type imaging system, other types of imaging systems, including lesser or greater reduction types may be used. Additionally, although the example chosen is employed as a lithography system, those of skill in the art will recognize that the methods described are equally applicable to other image projection systems, including EUV lithography systems flat panel lithography systems and bright field microscopes as non-limiting embodiments.

[0044] In one non-limiting embodiment, a method for testing is disclosed comprising projecting an illumination beam from an object having a pattern, passing the illumination beam through at least one imaging system, the imaging system having a pupil plane, the patterned beam passing through the pupil plane a first instance, reflecting the light beam off an arrangement back through the pupil in a second instance to a camera wherein the pupil plane and an image plane positions are switched and wherein the pupil plane is imaged on the camera instead of the object.

[0045] In another non-limiting embodiment, the method may further comprise comparing the pupil image received at the camera to an image of an ideal and desired intensity distribution.

[0046] In another non-limiting embodiment, the method may further comprise examining a symmetry of the illumination beam received at the camera using at least one image transducer pattern to determine how various patterns affect a light distribution in the pupil.

[0047] In another non-limiting embodiment, the method may further comprise passing the illumination beam through a frustrated prism assembly before passing a patterned light beam through the projection system.

[0048] In another non-limiting embodiment, the method may be performed wherein the reflecting the light beam off an arrangement back through the pupil, comprises: passing the light beam through a refractive lens and bouncing the light beam off a curved mirror.

[0049] In another non-limiting embodiment, the method may be performed wherein a refractive lens shifts an image plane to create a shifted focal plane for the light beam.

[0050] In another non-limiting embodiment, the method may be performed wherein a curved mirror of the arrangement images the pupil on to the shifted focal plane.

[0051] In a further embodiment, a device may be disclosed comprising: at least one optical element having a first refractive surface and a second reflective surface configured to be placed near an image plane, the at least one optical element configured to reverse a direction of light traveling through an imaging system and image a pupil onto an image plane and a mounting system configured to support the at least one optical element to a digital lithography system, wherein the mounting system allows for the at least one optical element to be moved from a first active position in the image plane to a second inactive position away from the image plane.

[0052] In another non-limiting embodiment, the device may further comprise a motor configured to position the at least one optical element.

[0053] In another non-limiting embodiment a device is disclosed comprising at least one optical element having a first convex surface and a second convex surface configured to be placed near an image plane of an imaging system, the at least one optical element configured to reverse a direction of light traveling through the imaging system and image a pupil of the imaging system onto an image plane, wherein the second convex surface is configured with a reflective coating, a mounting system configured to support the at least one optical element to a digital lithography system, wherein the mounting system allows for the at least one optical element to be moved from a first active position in the image plane to a second inactive position away from the image plane and at least one motor configured to move the mounting system from the first active position to the second inactive position.

[0054] In another non-limiting embodiment, the device may be provided wherein the at least one motor is computer controlled.

[0055] In another non-limiting embodiment, the device may be configured to comprise at least one optical element having a reflective surface configured to be placed near an image plane of an imaging system, the at least one optical element configured to reverse a direction of light traveling through the imaging system and image a pupil of a projection system onto an image plane, and a kinematic mounting arrangement configured to position the at least one optical element with respect to the projection system.

[0056] In another non-limiting embodiment, the device may be configured wherein the reflective surface is concave.

[0057] In one non-limiting embodiment, a method to test a projection system, is disclosed comprising illuminating one of an image transducer or a mask containing a pattern illuminated with a beam producing a patterned illumination beam, passing the patterned illumination beam through at least one imaging system, the imaging system having a pupil plane, the light beam passing through the pupil plane a first instance, moving a lens arrangement into the light beam that has passed through the pupil, reflecting the patterned illumination beam off of the lens arrangement to pass through the pupil in a second instance to image the pupil plane wherein an image plane and the pupil plane positions are switched by the lens arrangement,

receiving the patterned illumination beam at a camera and analyzing the pupil of the patterned illumination beam received at the camera.

[0058] In another non-limiting embodiment, the method may be performed wherein the moving of the lens arrangement into the light beam is through a motor.

[0059] In another non-limiting embodiment, the method may further comprise moving a kinematic mounting arrangement to position the at least one lens arrangement with respect to the projection system.

[0060] In another non-limiting embodiment, the method may be performed wherein the analyzing entails comparing the picture received at the camera to a desired intensity distribution.

[0061] In another non-limiting embodiment, the method may be performed wherein the analyzing entails determining an asymmetry of the picture received at the camera using various images to determine how asymmetry and therefore alignment accuracy varies with focus position and image composition.

[0062] In another non-limiting embodiment, the method may be performed wherein the camera is incorporated into the projection system.

[0063] In another non-limiting embodiment, the method may be performed wherein the reflecting the light beam off of the lens arrangement entails reflecting the light beam off a concave reflective surface.

[0064] While embodiments have been described herein, those skilled in the art, having benefit of this disclosure will appreciate that other embodiments are envisioned that do not depart from the inventive scope of the present application. Accordingly, the scope of the present claims or any subsequent related claims shall not be unduly limited by the description of the embodiments described herein.

What is claimed is:

1. A method for testing, comprising:
 - projecting an illumination beam from an object having a pattern;
 - passing the illumination beam through at least one imaging system, the imaging system having a pupil plane, the patterned beam passing through the pupil plane a first instance; and
 - reflecting the light beam off an arrangement back through the pupil in a second instance to a camera, wherein the pupil plane and an image plane positions are switched and wherein the pupil plane is imaged on the camera instead of the object.
2. The method according to claim 1, further comprising:
 - comparing the pupil image received at the camera to an image of an ideal and desired intensity distribution, or
 - examining a symmetry of the illumination beam received at the camera using at least one image transducer pattern to determine how various patterns affect a light distribution in the pupil, or
 - passing the illumination beam through a frustrated prism assembly before passing a patterned light beam through the projection system.
3. The method according to claim 1, wherein the reflecting the light beam off an arrangement back through the pupil, comprises:
 - passing the light beam through a refractive lens; and
 - bouncing the light beam off a curved mirror.
4. The method according to claim 1, wherein the refractive lens shifts an image plane to create a shifted focal plane for the light beam.
5. The method according to claim 4, wherein a curved mirror of the arrangement images the pupil on to the shifted focal plane.

6. A device, comprising:
 - at least one optical element having a first refractive surface and a second reflective surface configured to be placed near an image plane, the at least one optical element configured to reverse a direction of light traveling through an imaging system and image a pupil onto an image plane; and
 - a mounting system configured to support the at least one optical element to a digital lithography system, wherein the mounting system allows for the at least one optical element to be moved from a first active position in the image plane to a second inactive position away from the image plane.
7. The device according to claim 6, further comprising a motor configured to position the at least one optical element.
8. The device according to claim 6, further comprising at least one motor configured to move the mounting system from the first active position to the second inactive position.
9. The device according to claim 8, wherein the at least one motor is computer controlled.
10. A method to test a projection system, comprising:
 - illuminating one of an image transducer or a mask containing a pattern with a beam producing a patterned illumination beam;
 - passing the patterned illumination beam through at least one imaging system, the imaging system having a pupil plane, the light beam passing through the pupil plane a first instance;
 - moving a lens arrangement into the light beam that has passed through the pupil;
 - reflecting the patterned illumination beam off of the lens arrangement to pass through the pupil in a second instance to image the pupil plane wherein an image plane and the pupil plane positions are switched by the lens arrangement;
 - receiving the patterned illumination beam at a camera; and
 - analyzing the pupil of the patterned illumination beam received at the camera.

11. The method according to claim 10, wherein the moving of the lens arrangement into the light beam is through a motor.
12. The method according to claim 10, wherein the analyzing entails comparing the picture received at the camera to a desired intensity distribution, or
13. The method according to claim 10, wherein the analyzing entails determining an asymmetry of the picture received at the camera using various images to determine how asymmetry and therefore alignment accuracy varies with focus position and image composition.
14. The method according to claim 10, further comprising:
moving a kinematic mounting arrangement to position the at least one lens arrangement with respect to the projection system.
15. The method according to claim 10, wherein
the camera is incorporated into the projection system, or
the reflecting the light beam off of the lens arrangement entails reflecting the light beam off a concave reflective surface.

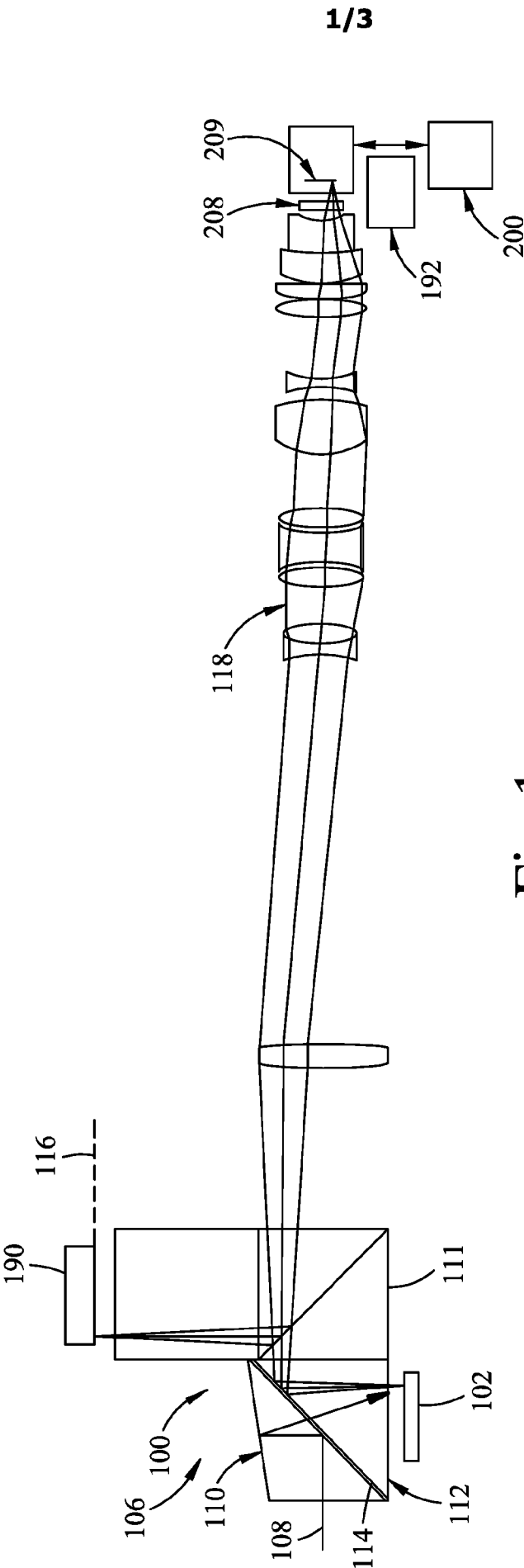


Fig. 1

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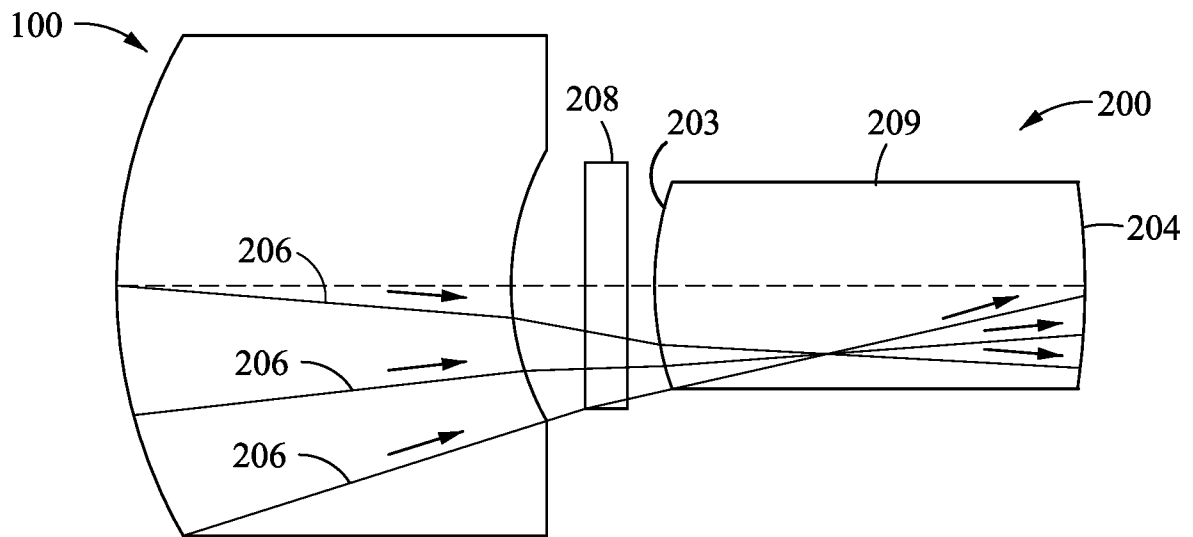


Fig. 2

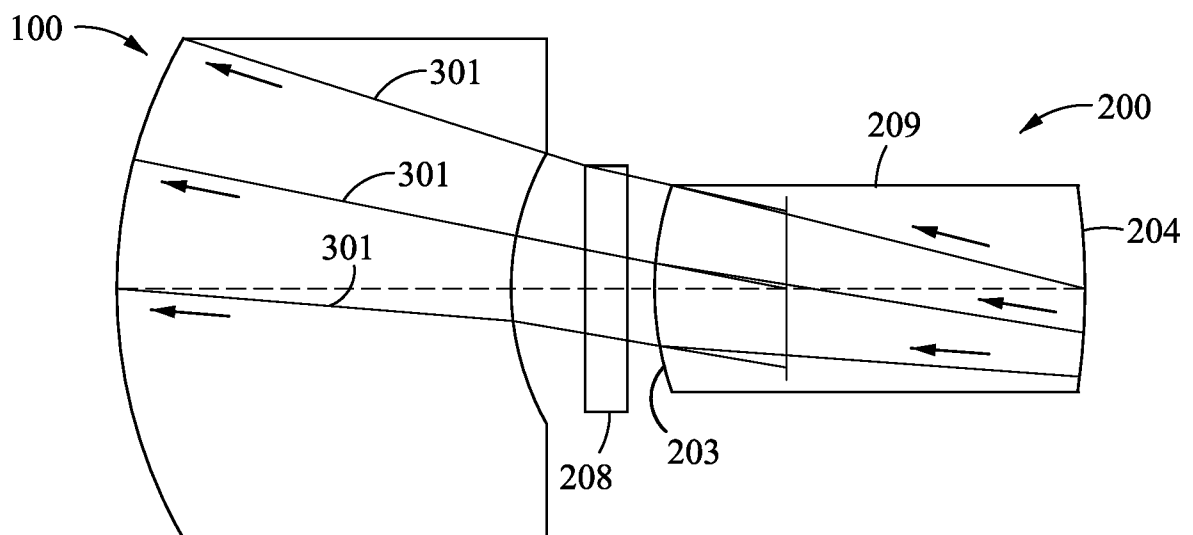


Fig. 3

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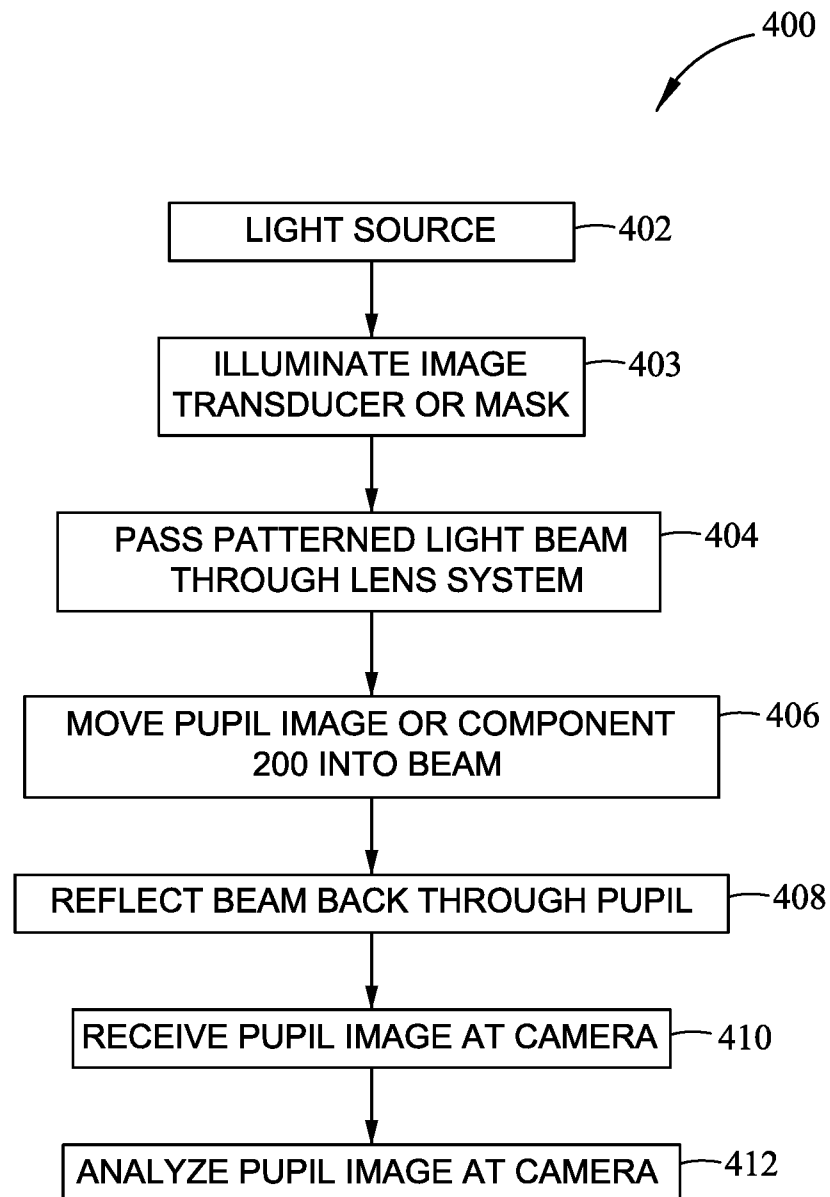


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2019/035063**A. CLASSIFICATION OF SUBJECT MATTER****H04N 9/31(2006.01)i, G03B 43/00(2006.01)i**

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

B. FIELDS SEARCHEDMinimum documentation searched (classification system followed by classification symbols)
H04N 9/31; G01J 1/04; G02B 13/00; G03F 7/00; G03F 7/20; H01L 21/027; G03B 43/00Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility modelsElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: lithography projection system, patterned beam, pupil plane, image plane, switch, intensity distribution, symmetry, lens arrangement, motor**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	KR 10-1119723 B1 (CARL ZEISS SMT GMBH) 23 March 2013 See paragraphs [0056]-[0057]; claims 1, 4; and figure 1.	1-5, 10-15
X	KR 10-2014-0141660 A (ASML NETHERLANDS B.V.) 10 December 2014 See paragraph [0018]; claims 1-2, 8-11, 13; and figure 1.	6-9
Y		1-5, 10-15
Y	KR 10-1738288 B1 (CARL ZEISS SMT GMBH) 19 May 2017 See paragraphs [0008]-[0009]; and claim 1 .	2
Y	KR 10-2018-0030722 A (KLA-TENCOR LIMITED COMPANY) 23 March 2018 See paragraph [0091]; and claim 9.	12-13
A	KR 10-1763092 B1 (CARL ZEISS SMT GMBH) 28 July 2017 See paragraphs [0028]-[0029].	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search

20 September 2019 (20.09.2019)

Date of mailing of the international search report

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Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea

Facsimile No. +82-42-481-8578

Authorized officer

AHN, Jeong Hwan

Telephone No. +82-42-481-8633



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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