

description

Technical Field

This invention relates to mask aligning methods, and, more particularly, to methods for aligning photolithographic masks (photomasks) on opposite sides of a flat workpiece.

Background of the Invention

Photolithographic masking and etching is widely understood because of its extensive use in the fabrication of integrated circuits. In such processes, a semiconductor wafer is coated with a thin layer of photoresist material and is exposed to actinic light through a patterned photomask. After development, the photoresist coating itself acts as a mask to permit selective processing, such as selective etching, of the wafer.

It has been found that the same process is useful for making optic fiber connectors from silicon wafers. Each connector comprises a silicon chip having grooves on opposite sides which are used to contain optic fibers and to align the connector. Since the alignment of optic fibers for lightwave transmission is extremely critical, it is important that the support grooves be accurately located to within tolerances that are typically less than one micron. For this reason, in the fabrication of such connectors, it is critical to align accurately photomasks on opposite sides of a semiconductor wafer that has been coated with photoresist material.

The U.S. Patent of K.H. Chou, 3,963,489, issued June 15, 1976, is an example of prior art teachings of methods for aligning photomasks on opposite sides of a semiconductor wafer. The Chou technique uses indexing indicia on corresponding portions of the two photomasks that overlap the wafer contained between them. By properly aligning these indicia, one aligns the mask patterns of the two masks with respect to the intervening semiconductor wafer.

A problem with using a scheme such as this for aligning masks with submicron tolerances is that a sufficiently high-power microscope for making the alignment will normally have a smaller depth of field than the separation of the two masks. Thus, the operator cannot see both alignment indicia simultaneously during the alignment operation. One way of meeting this problem would be to align the two masks while they are in close contact and then separate them to incorporate the wafer. In practice, it has been found to be extremely difficult, if not impossible, to make the required mechanical separation while maintaining the required close tolerances.

Patent Abstract of Japan, Vol. 7, No. 206 (p-222) (1351) 10th September 1983 discloses a method of aligning by means of two slits.

According to the present invention there is provided a method as defined in claim 1.

In accordance with the invention, these problems are solved by making a plurality of zone plates on the periphery of one of the masks and a plurality of transparent slits on the periphery of the other mask, each slit being aligned with a corresponding zone plate. The masks are then conveniently aligned on opposite sides of a wafer by directing collimated light through one of the zone plates and then moving the masks relative to each other until the light beam focused by the zone plate is transmitted through a corresponding transparent slit. Three zone plates with corresponding transparent slits may be used for aligning the mask in X, Y and angular (or θ) directions.

Transmission of the light beam through a transparent slit is conveniently detected automatically by a light detector. As will be explained in more detail below, a high degree of alignment accuracy can be obtained by scanning the light beam across the transparent slit, making three light intensity measurements during the scan and using a computer to fit the three intensity points to a parabolic curve. The computer can then determine the maximum of the parabolic curve, which will then correspond to the center of the transparent slit and move the mask relative to the light beam to get precise centering of the light beam on the slit.

Brief Description of the Drawing

FIG. 1 is a schematic illustration of apparatus for aligning photomasks in accordance with one embodiment of the invention;

FIG. 2 is a schematic illustration of mask alignment and exposure apparatus in accordance with another embodiment of the invention;

FIG. 3 is an expanded view of a portion of the apparatus of FIG. 2.

FIG. 4 is a graph of light intensity vs. distance generated by the light beam shown in FIG.3; and

FIG. 5 is a graph of light power vs. distance as generated by the apparatus of FIGS. 2 and 3.

Detailed Description

Referring now to FIG. 1, there are shown schematically first and second photomasks 11 and 12 for illustrating the general principles of the invention. For purposes of expediency, neither the pattern of the photomasks nor the wafer between them which is to be exposed has been shown. The only devices shown are those for aiding in mask align-

nent.

Arranged around a periphery of the lower photomask 11 are three zone plates 13A, 13B, and 13C. Aligned respectively with the zone plates on the upper photomask 12 are three transparent slits 14A, 14B, and 14C. As is known, zone plates are diffraction elements, which, when arranged in the shape of concentric circles, may act as circular lenses. Both the zone plates 13A-C and the transparent slits 14A-C may conveniently be made at the same time that the photolithographic mask patterns in the photomasks are made.

Light from light sources 16A-C, which may be optic fibers, is collimated by collimating lenses 17A-C and is directed through the zone plates 13A-C. The zone plates focus the light into beams which, when the masks are properly aligned, are transmitted through the corresponding transparent slits 14A-C.

In accordance with the invention, the masks are aligned by moving the upper photomask 12 in X, Y and θ directions relative to the lower mask 11 until the three focused beams are transmitted through the three slits 14A-C. Preferably, the upper photomask 12 is moved in a Y direction until focused light from zone plate 13A is transmitted through transparent slit 14A and detected by photodetector 18A. After initial detection, the photomask 12 may be slowly scanned in the Y direction to determine the position at which light transmitted through opening 14A is at a maximum. The position of maximum light power transmission of course indicates a precise centering of the transparent slit with respect to the light beam. The slits 14A-C have a long dimension transverse to the direction of scan during alignment. For example, slit 14A, used for Y direction alignment, has a long dimension in the X direction. Slits 14C and 14B are arranged along a line parallel to the Y axis.

After Y direction alignment, the upper photomask is scanned in the X direction until light is initially detected by detectors 18B and 18C. An angular adjustment is made so that light is detected simultaneously by both detectors, 18B and 18C during a scan. Such adjustments may be made after repetitive slow X-direction scans to obtain maximum light power detection simultaneously by the detectors 18B and 18C, which indicates both X-direction and θ alignment. After alignment in all three directions, as indicated by maximum power output of all thru detectors 18A-C, masks 11 and 12 are fixed for exposure of the wafer.

FIG. 2 shows schematically a photomask alignment system in accordance with the invention that has been successfully used in the fabrication of optic fiber connectors. Elements having the same reference numbers as those of FIG. 1 perform the same functions and, for expediency, will not be

further explained; however, it is the lower photomask that is actually moved into alignment, rather than the upper photomask as in FIG. 1.

A photomask holder 20 supports photomask 11 and is driven by a stepper motor 21 in X and θ directions as shown. Lenses 17B and 17C and optic fiber light sources 16B and 16C are fixed by an encapsulation to photomask 11 and are driven with it. Photomasks 11 and 12 are arranged on opposite sides of a silicon wafer (not shown) to be processed. The wafer is coated with a photoresist on top and bottom surfaces and both photomasks contain patterns to be transferred to the silicon wafer. After alignment, ultraviolet sources 24 and 25 expose the photoresist through the photomasks to define the patterns that are subsequently used to control etching of the silicon wafer. After masking and etching, the wafer is cut into chips that are thereafter used as optic fiber connectors.

The construction of holder 20 and the particular etching requirements for the wafer are such that the highly critical alignment capabilities of the invention are not required for alignment in the Y direction. Specifically, the apparatus is intended for the fabrication of optical fiber connectors which require grooves on opposite sides of a chip that are extremely accurately aligned in the X and θ directions for accurate intermeshing with the other elements. Notice that for θ alignment, the holder 20 is rotated about an axis that is removed from photomasks 11 and 12.

The photomasks, portions of which are shown in greater detail in FIG. 2, are essentially glass plates. The mask pattern and the transparent slits are formed on the lower surface of photomask 12, while the zone plates and lower photomask pattern are formed on the upper surface of photomask 11. Slit 14B and zone plate 13B are shown in FIG. 3. The transparent slits and the zone plates can conveniently be made by photolithographic masking and etching simultaneously with the formation of the mask patterns on photomasks 11 and 12 and by the same process.

The light sources 16B and 16C are optic fibers for transmitting light from a remote source and lenses 17B and 17C are glass lenses for collimating light from the optic fibers. The outputs of light detectors 18B and 18C are directed to a computer 27 which controls the stepper motor 21. The computer is programmed, using known techniques, to align the masks automatically in accordance with the invention.

While the computer could be programmed to detect maximum light intensity through the slit, as has been described above, a more sophisticated method has been found for more accurately centering the slit on the focused beam. The light beam focused on the slit, or on the upper photomask 12

for to alignment, has an intensity distribution as shown by curve 29 of FIG. 4. Curve 29, the light distribution resulting from zone plate focusing, is known in the art as an Airy function. The spot size is taken as the distance d between curve segments at one-half the maximum intensity. As the spot illustrated in FIG. 4 is scanned across the rectangular slit, the resultant light power, or integrated light intensity, detected by the photodetector varies with distance, as shown by curve 30 of FIG. 5. Curve 30 is known mathematically as a convolution of the curve 29 of FIG. 4 and of the rectangular slit. Point 31 represents the distance along the scan at which light begins to enter the slit and point 32 is the point at which the light beam leaves the slit. Since the spot has a finite width, the distance between 31 and 32 is somewhat greater than the actual width of the slit.

Detection of the precise maximum, as mentioned before, may be somewhat difficult because the rate of change of slope of the curve at its maximum is relatively small. Instead, after the slit has initially been detected, a slow stepped scan is made such that three equally spaced samples of light output are taken as the beam traverses the slit. The computer fits these samples to a parabolic function to determine the location of the central peak. The initiation of a subsequent scan is adjusted to make the function more centered, and the operation is iterated until centering is achieved.

With three samples, centering occurs when the two outer samples are equal. For example, assume that the set of samples taken during the first slow scan were points 34, 35 and 36. Since the value of point 34 is lower than point 36, the successive scan must be initiated at a location displaced slightly to the right. This will move point 34 "up the curve" and point 36 "down the curve". When the light power at points 34 and 36 is equal, then point 35 can be taken as being at the center of the slit and precise alignment is obtained. Such alignment is automatic and is made to tolerances of less than one micron.

During the rapid first scan for making the initial light detection, the scan steps were each 2.5 microns. The slit width was 0.5 microns. During the slow scan, each step was 1.5 microns, which was appropriate for giving three readings within the slit width. The one-half maximum spot size was 2.5 microns; however, the detectable spot size width was significantly larger.

The angular or θ alignment is done in conjunction with the X-direction alignment. The extent to which light is not detected simultaneously by the two detectors, and the order in which light is detected, indicates the magnitude and direction of angular misalignment. The computer is programmed to make a θ adjustment during both the

fast scans and the slow scans. After each show scan, both the initial location of the successive scan and the angular location of the mask are adjusted and scanning is repeated until accurate centering of both beams on both slits is simultaneously obtained. After alignment, the masks are fixed on opposite sides of the wafer and exposures of both sides of the wafer by sources 24 and 25 are made.

The specific embodiments described are intended to be merely illustrative of the invention. Other radiative forms may be the functional equivalents of light beams. Relative movement of the beam with respect to the transparent slit implies that either the beam or the slit may be stationary.

Claims

1. A method for fabricating devices from a flat member, comprising the steps of coating the member with photoresist material, aligning planar first and second masks on opposite sides of the member, exposing the masked photosensitive material to actinic light, developing the photosensitive material and using the developed photosensitive coating as a mask for selectively processing the flat member, characterized by the steps of:

forming at least a first zone plate in the first mask;

forming at least a first transparent slit in the second mask at a predetermined location with respect to the location in the first mask of the first zone plate; and

wherein the alignment step comprises the step of directing a light beam through the first zone plate toward the second mask and moving the second mask relative to the first mask until the light beam is transmitted through the first transparent slit.

2. The method of claim 1 further characterized by the steps of:

forming a second zone plate in the first mask;

forming a second transparent slit in the second mask; and

wherein the alignment step further comprises the steps of directing a light beam through the second zone plate toward the second mask and moving the second mask relative to the first mask until the second light beam is transmitted through the second transparent slit.

3. The method of claim 1 further characterized in that:

after the light beam is first transmitted



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With three samples, centering occurs when the two outer samples are equal. For example, assume that the set of samples taken during the first slow scan were points 34, 35 and 36. Since the value of point 34 is lower than point 36, the successive scan must be initiated at a location displaced slightly to the right. This will move point 34 "up the curve" and point 36 "down the curve". When the light power at points 34 and 36 is equal, then point 35 can be taken as being at the center of the slit and precise alignment is obtained. Such alignment is automatic and is made to tolerances of less than one micron.

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fast scans and the slow scans. After each show scan, both the initial location of the successive scan and the angular location of the mask are adjusted and scanning is repeated until accurate centering of both beams on both slits is simultaneously obtained. After alignment, the masks are fixed on opposite sides of the wafer and exposures of both sides of the wafer by sources 24 and 25 are made.

The specific embodiments described are intended to be merely illustrative of the invention. Other radiative forms may be the functional equivalents of light beams. Relative movement of the beam with respect to the transparent slit implies that either the beam or the slit may be stationary.

Claims

1. A method for fabricating devices from a flat member, comprising the steps of coating the member with photoresist material, aligning planar first and second masks on opposite sides of the member, exposing the masked photosensitive material to actinic light, developing the photosensitive material and using the developed photosensitive coating as a mask for selectively processing the flat member, characterized by the steps of:

forming at least a first zone plate in the first mask;

forming at least a first transparent slit in the second mask at a predetermined location with respect to the location in the first mask of the first zone plate; and

wherein the alignment step comprises the step of directing a light beam through the first zone plate toward the second mask and moving the second mask relative to the first mask until the light beam is transmitted through the first transparent slit.

2. The method of claim 1 further characterized by the steps of:

forming a second zone plate in the first mask;

forming a second transparent slit in the second mask; and

wherein the alignment step further comprises the steps of directing a light beam through the second zone plate toward the second mask and moving the second mask relative to the first mask until the second light beam is transmitted through the second transparent slit.

3. The method of claim 1 further characterized in that:

after the light beam is first transmitted



through the first transparent slit, the second mask is moved relative to the first mask such as to cause the light beam to scan the width of the first transparent slit;

during such scan a plurality of measurements of light intensity through the slit is made;

the measurements are fitted to a parabola; and

thereafter the parabola is used to locate the second mask such that the center of the first transparent slit substantially coincides with the center of the light beam.

4. The method of claim 3 further characterized in that:

the light beam is caused to scan the width of the first transparent slit repetitively;

during each scan, three measurements of light intensity through the slit are made;

after each scan, the location of the initiation of successive scans is changed until two of the three measurements are substantially equal and the three measurements of light intensity vs. distance substantially describe a parabola; and

such parabola is used to center the first transparent slit on the light beam.

5. The method of claim 1 further characterized in that:

the step of moving the second mask relative to the first mask comprises the step of fixing the second mask with respect to a reference structure and moving the first mask relative to the reference structure, and wherein the light beam is fixed with respect to the first mask.

6. A method for aligning first and second planar members, comprising the step of forming first and second zone plates in the first planar member, forming first and second transparent openings in the second member so as to be aligned, respectively, with the first and second zone plates, locating first and second photodetectors, respectively, adjacent the first and second openings and opposite the first planar member, directing a first light beam through the first zone plate toward the second planar member, directing a second light beam through the second zone plate toward the second member, and moving the second member relative to the first member until the first beam is transmitted through the first opening and is detected by the first light detector and the second light beam is simultaneously transmitted through the second opening and detected

by the second detector.

7. The method of claim 6 wherein the step of moving the second member relative to the first member comprises the step of moving the second member relative to the first member in an X linear direction.
8. The method of claim 7 wherein the step of moving the second planar member relative to the first planar member comprises the step of maintaining the second member stationary with respect to a reference structure and moving the first member relative to the reference structure, and wherein the first and second light beams are fixed with input to first member.
9. The method of claim 7 wherein the step of moving the second member relative to the first member comprises the step of moving the second member relative to the first member in an angular direction.
10. The method of claim 6 further comprising the steps of forming a third zone plate in the first planar member, forming a third transparent opening in the second member so as to be aligned with the third zone plate, locating a third photodetector adjacent the third opening and opposite the first planar member, directing a third light beam through the third zone plate toward the second member, and moving the second member relative to the first member until the third beam is transmitted through the third opening and is detected by the third light detector.
11. The method of claim 10 wherein the step of moving the second planar member until the first and second light beams are respectively detected by the first and second light detectors comprises the step of moving the second planar member relative to the first member in an X linear direction, and then moving the second planar member relative to the first member in an angular direction, and the step of moving the second member until the third light beam is detected comprises the step of moving the second planar member relative to the first member in a Y linear direction which is transverse to the X direction.
12. The method of claim 6 wherein the second member is located with respect to the first member such that a maximum light intensity of the first light beam is detected by the first light detector, and a maximum light intensity of the



second light beam is detected by the second light detector.

13. The method of claim 12 wherein the first and second light beams are respectively caused to scan the widths of the first and second openings repetitively, three equally-spaced measurements of light intensity through each opening are made, and after each scan the location of the initiation of the successive scan and the angular orientation of the second mask are changed until two of the three measurements are substantially equal and the three measurements of light intensity vs. distance each substantially describe a parabola, and the parabolas are used to center, respectively, the first opening on the first beam and the second opening on the second beam.

Patentansprüche

1. Verfahren zur Herstellung von Vorrichtungen aus einem flachen Teil, mit folgenden Schritten: Beschichten des Teils mit Fotowiderstandsmaterial, Ausrichten von ebenen ersten und zweiten Masken auf entgegengesetzten Seiten des Teils, Belichten des maskierten fotoempfindlichen Materials mit aktinischem Licht, Entwickeln des fotoempfindlichen Materials und Benutzen der entwickelten fotoempfindlichen Beschichtung als Maske zur wahlweisen Verarbeitung des flachen Teils, gekennzeichnet durch folgende Schritte: mindestens eine erste Zonenplatte wird in der ersten Maske gebildet; mindestens ein erster transparenter Schlitz wird in der zweiten Maske an vorbestimmter Stelle gebildet, und zwar mit Bezug auf die Stelle in der ersten Maske der ersten Zonenplatte, und worin der Ausrichteschritt folgenden Schritt umfaßt: ein Lichtstrahlenbündel wird durch die erste Zonenplatte zur zweiten Maske gerichtet und die zweite Maske wird relativ zur ersten Maske bewegt, bis der Lichtstrahlenbündel durch den ersten transparenten Schlitz hindurchfällt.
2. Verfahren nach Anspruch 1, gekennzeichnet durch folgende weitere Schritte: in der ersten Maske wird eine zweite Zone gebildet; in der zweiten Maske wird ein zweiter transparenter Schlitz gebildet; und worin der Ausrichteschritt folgenden weiteren Schritt umfaßt: ein Lichtstrahlenbündel wird durch die zweite

Zonenplatte zur zweiten Maske gerichtet, und die zweite Maske wird relativ zur ersten Maske bewegt, bis das zweite Strahlenbündel durch den zweiten transparenten Schlitz hindurchtritt.

3. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß, nachdem der Lichtstrahlenbündel zunächst durch den ersten transparenten Schlitz hindurchgetreten ist, die zweite Maske relativ zur ersten Maske so bewegt wird, daß der Lichtstrahl dazu gebracht wird, die Breite des ersten transparenten Schlitzes abzutasten; daß während dieser Abtastung eine Mehrzahl von Messungen der Lichtintensität durch den Schlitz durchgeführt wird; daß die Meßwerte zu einer Parabel zusammengesetzt werden, und daß die Parabel danach zur Justierung der zweiten Maske benutzt wird, derart, daß die Mitte des ersten transparenten Schlitzes im wesentlichen mit der Mitte des Lichtstrahls zusammenfällt.
4. Verfahren nach Anspruch 3, dadurch gekennzeichnet, daß das Lichtstrahlenbündel dazu gebracht wird, die Breite des ersten transparenten Schlitzes wiederholt abzutasten, daß während jeder Abtastung drei Messungen der Lichtintensität durch den Schlitz gemacht werden, daß nach jeder Abtastung die Stelle des Beginns der nachfolgenden Abtastung gewechselt wird, bis zwei der drei Meßwerte im wesentlichen gleich sind, daß die drei Meßwerte der Lichtintensität über der zurückgelegten Wegstrecke im wesentlichen eine Parabel beschreiben, und daß eine solche Parabel zur Zentrierung des ersten transparenten Schlitzes auf das Lichtstrahlenbündel benutzt wird.
5. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß der Schritt der Verschiebung der zweiten Maske relativ zur ersten Maske folgenden Schritt umfaßt: die zweite Maske wird mit Bezug auf eine Referenzstruktur fixiert, und die erste Maske wird relativ zur Referenzstruktur verschoben, und daß das Lichtstrahlenbündel mit Bezug auf die erste Maske fixiert ist.
6. Verfahren der Ausrichtung erster und zweiter ebener Teile, mit folgenden Schritten: erste und zweite Zonenplatten werden in dem ersten ebenen Teil gebildet, in dem zweiten Teil werden erste und zweite



transparente Öffnungen so gebildet, daß diese jeweils zu den ersten und zweiten Zonenplatten ausgerichtet sind,

erste und zweite Fotodetektoren werden jeweils benachbart den ersten und zweiten Öffnungen und gegenüber dem ersten ebenen Teil angeordnet,

ein erstes Lichtstrahlenbündel wird durch die erste Zonenplatte zu dem zweiten ebenen Teil hin gerichtet, ein zweites Lichtstrahlenbündel wird durch die zweite Zonenplatte zum zweiten Teil hin gerichtet, und daß zweite Teil wird relativ zum ersten Teil so lange verschoben, bis der erste Lichtstrahlenbündel durch die erste Öffnung übertragen und von dem ersten Lichtdetektor festgestellt wird, und der zweite Lichtstrahlenbündel wird gleichzeitig durch die zweite Öffnung übertragen und von dem zweiten Detektor festgestellt.

7. Verfahren nach Anspruch 6, worin der Schritt der Verschiebung des zweiten Teils relativ zu dem ersten Teil den Schritt der Verschiebung des zweiten Teils relativ zu dem ersten Teil in einer linearen Richtung X umfaßt.

8. Verfahren nach Anspruch 7, worin der Schritt der Verschiebung des zweiten ebenen Teils relativ zu dem ersten ebenen Teil den Schritt umfaßt, daß das zweite Teil mit Bezug auf eine Referenzstruktur stationär gehalten wird und das erste Teil relativ zu der Referenzstruktur verschoben wird und worin die ersten und zweiten Lichtstrahlenbündel mit einem Eingang zum ersten Teil fixiert werden.

9. Verfahren nach Anspruch 7, worin der Schritt der Verschiebung des zweiten Teils relativ zu dem ersten Teil den Schritt der Verschiebung des zweiten Teils relativ zu dem ersten Teil in einer Winkelrichtung umfaßt.

10. Verfahren nach Anspruch 6, mit folgenden weiteren Schritten:
in dem ersten ebenen Teil wird eine dritte Zonenplatte gebildet;
in dem zweiten Teil wird eine dritte transparente Öffnung so gebildet, daß diese zu der dritten Zonenplatte fluchtet;
ein dritter Fotodetektor wird benachbart der dritten Öffnung und gegenüber dem ersten ebenen Teil angeordnet; ein drittes Lichtstrahlenbündel wird durch die dritte Zonenplatte zu dem zweiten Teil hin gerichtet, und das zweite Teil wird relativ zu dem ersten Teil so lange verschoben, bis das dritte Strahlenbündel

durch die dritte Öffnung hindurchtritt und von dem dritten Lichtdetektor nachgewiesen wird.

11. Verfahren nach Anspruch 10, worin der Schritt der Verschiebung des zweiten ebenen Teils, bis die ersten und zweiten Lichtstrahlen jeweils von den ersten und zweiten Lichtdetektoren nachgewiesen werden, folgenden Schritt umfaßt:

das zweite ebene Teil wird relativ zu dem ersten ebenen Teil in einer linearen Richtung X verschoben,

danach wird das zweite ebene Teil relativ zu dem ersten Teil winkelmäßig bewegt, und

der Schritt der Verschiebung des zweiten Teils, bis der dritte Lichtstrahlenbündel nachgewiesen wird, umfaßt den Schritt der Verschiebung des zweiten ebenen Teils relativ zu dem ersten Teil in einer linearen Richtung Y, die quer zur X-Richtung ist..

12. Verfahren nach Anspruch 6, worin das zweite Teil mit Bezug auf das erste Teil einjustiert wird, derart, daß eine maximale Lichtintensität des ersten Lichtstrahlenbündels durch den ersten Lichtdetektor festgestellt wird und eine maximale Lichtintensität des zweiten Lichtstrahls von dem zweiten Lichtdetektor nachgewiesen wird.

13. Verfahren nach Anspruch 12, worin die ersten und zweiten Lichtstrahlenbündel jeweils dazu gebracht werden, die Breiten der ersten bzw. der zweiten Öffnung abzutasten, daß drei Lichtintensitätsmessungen im gleichen Abstand durch jede Öffnung gemacht werden und daß nach jeder Abtastung die Stelle des Beginns der nachfolgenden Abtastung und die winkelmäßige Ausrichtung der zweiten Maske geändert werden, bis zwei der drei Meßwerte im wesentlichen gleich sind und die drei Meßwerte der Lichtintensität, auf der zugeordneten Strecke aufgetragen, jeweils im wesentlichen eine Parabel beschreiben, und daß die Parabel zur jeweiligen Zentrierung der ersten Öffnung zum ersten Strahlenbündel und der zweiten Öffnung zum zweiten Strahlenbündel benutzt werden.

Revendications

1. Un procédé de fabrication de dispositifs à partir d'un article plat, comprenant les étapes qui consistent à revêtir l'article avec une matière de réserve photographique, à aligner des premier et second masques plans sur des faces opposées de l'article, à exposer à de la lumière actinique la matière photosensible masquée,



à développer la matière photosensible et à utiliser le revêtement photosensible développé à titre de masque pour traiter sélectivement l'article plat, caractérisé par les étapes suivantes :

on forme au moins un premier réseau zoné dans le premier masque ;

on forme au moins une première fente transparente dans le second masque, à un emplacement prédéterminé par rapport à l'emplacement du premier réseau zone dans le premier masque ; et

l'étape d'alignement comprend l'étape qui consiste à diriger un faisceau de lumière à travers le premier réseau zoné, en direction du second masque, et à déplacer le second masque par rapport au premier masque jusqu'à ce que le faisceau de lumière soit transmis à travers la première fente transparente.

2. Le procédé de la revendication 1, caractérisé en outre par les étapes suivantes :

on forme un second réseau zoné dans le premier masque ;

on forme une seconde fente transparente dans le second masque ; et

l'étape d'alignement comprend en outre les étapes qui consistent à diriger un faisceau de lumière à travers le second réseau zoné, en direction du second masque, et à déplacer le second masque par rapport au premier masque, jusqu'à ce que le second faisceau de lumière soit transmis à travers la seconde fente transparente.

3. Le procédé de la revendication 1, caractérisé en outre en ce que :

après que le faisceau de lumière a été transmis initialement à travers la première fente transparente, on déplace le second masque par rapport au premier masque de façon que le faisceau de lumière balaye la largeur de la première fente transparente ;

pendant ce balayage, on effectue un ensemble de mesures d'intensité lumineuse à travers la fente ;

on détermine une parabole correspondant aux valeurs mesurées ; et

on utilise ensuite la parabole pour placer le second masque de façon que le centre de la première fente transparente coïncide pratiquement avec le centre du faisceau de lumière.

4. Le procédé de la revendication 3, caractérisé en outre en ce que :

on déplace le faisceau de lumière de façon à balayer d'une manière répétitive la largeur de la première fente transparente ;

pendant chaque balayage, on effectue trois mesures d'intensité lumineuse à travers la fente ;

après chaque balayage, on change la position du déclenchement de balayages successifs, jusqu'à ce que deux des trois mesures soient pratiquement égales, et que les trois mesures d'intensité lumineuse en fonction de la distance définissent pratiquement une parabole ; et

on utilise cette parabole pour centrer la première fente transparente sur le faisceau de lumière.

5. Le procédé de la revendication 1, caractérisé en outre en ce que :

l'étape de déplacement du second masque par rapport au premier masque comprend l'étape qui consiste à fixer le second masque par rapport à une structure de référence et à déplacer le premier masque par rapport à la structure de référence, le faisceau de lumière étant placé d'une manière fixe par rapport au premier masque.

6. Un procédé d'alignement d'un premier et d'un second éléments plans, comprenant les étapes suivantes : on forme des premier et second réseaux zonés dans le premier élément plan, on forme des première et seconde ouvertures transparentes dans le second élément plan, de façon qu'elles soient respectivement alignées avec les premier et second réseaux zonés, on place respectivement des premier et second photodétecteurs dans des positions adjacentes aux première et seconde ouvertures, et du côté opposé au premier élément plan, on dirige un premier faisceau de lumière à travers le premier réseau zoné, vers le second élément plan, on dirige un second faisceau de lumière à travers le second réseau zoné, vers le second élément, et on déplace le second élément par rapport au premier élément jusqu'à ce que le premier faisceau soit transmis à travers la première ouverture et soit détecté par le premier détecteur de lumière, et le second faisceau de lumière soit transmis simultanément à travers la seconde ouverture et soit détecté par le second détecteur.

7. Le procédé de la revendication 6 dans lequel l'étape de déplacement du second élément par rapport au premier élément comprend l'étape qui consiste à déplacer le second élément par rapport au premier élément dans une direction linéaire X.

8. Le procédé de la revendication 7, dans lequel



- l'étape de déplacement du second élément plan par rapport au premier élément plan comprend l'étape qui consiste à maintenir le second élément fixe par rapport à une structure de référence, et à déplacer le premier élément par rapport à la structure de référence, et dans lequel les premier et second faisceaux de lumière sont fixes par rapport au premier élément.
9. Le procédé de la revendication 7, dans lequel l'étape de déplacement du second élément par rapport au premier élément comprend l'étape qui consiste à déplacer le second élément par rapport au premier élément dans une direction angulaire.
10. Le procédé de la revendication 6, comprenant en outre les étapes qui consistent à former un troisième réseau zoné dans le premier élément plan, à former une troisième ouverture transparente dans le second élément, de façon qu'elle soit alignée avec le troisième réseau zoné, à placer un troisième photodétecteur en position adjacente à la troisième ouverture et du côté opposé au premier élément plan, à diriger un troisième faisceau de lumière à travers le troisième réseau zoné, vers le second élément, et à déplacer le second élément par rapport au premier élément jusqu'à ce que le troisième faisceau soit transmis à travers la troisième ouverture et soit détecté par le troisième détecteur de lumière.
11. Le procédé de la revendication 10, dans lequel l'étape de déplacement du second élément plan jusqu'à ce que les premier et second faisceaux de lumière soient respectivement détectés par les premier et second détecteurs de lumière, comprend les étapes qui consistent à déplacer le second élément plan par rapport au premier élément dans une direction linéaire X, et à déplacer ensuite le second élément plan par rapport au premier élément dans une direction angulaire, et l'étape de déplacement du second élément jusqu'à ce que le troisième faisceau de lumière soit détecté comprend l'étape qui consiste à déplacer le second élément plan par rapport au premier élément dans une direction linéaire Y qui est transversale par rapport à la direction X.
12. Le procédé de la revendication 6, dans lequel le second élément est placé par rapport au premier élément de façon que le premier détecteur de lumière détecte une intensité lumineuse maximale du premier faisceau de lumière, et que le second détecteur de lumière
- détecte une intensité lumineuse maximale du second faisceau de lumière.
13. Le procédé de la revendication 12, dans lequel les premier et second faisceaux de lumière sont respectivement déplacés de façon à balayer les largeurs des première et seconde ouvertures, trois mesures équidistantes d'intensité lumineuse sont effectuées à travers chaque ouverture, et après chaque balayage la position du déclenchement du balayage successif et l'orientation angulaire du second masque sont changées jusqu'à ce que deux des trois mesures soient pratiquement égales et que les trois mesures d'intensité lumineuse en fonction de la distance définissent pratiquement une parabole, et ces paraboles sont utilisées pour centrer respectivement la première ouverture sur le premier faisceau et la seconde ouverture sur le second faisceau.