METHOD OF PRODUCING OPTICAL LENS, AND OPTICAL LENS

VERFAHREN ZUR HERSTELLUNG EINER OPTISCHEN LINSE, UND OPTISCHE LINSE

PROCEDE DE FABRICATION D'UNE LENTILLE OPTIQUE, ET LENTILLE OPTIQUE

Designated Contracting States:
DE FR GB

Priority: 09.05.2001 JP 2001139226

Date of publication of application:
03.03.2004 Bulletin 2004/10

Proprietor: HAMAMATSU PHOTONICS K.K.
Hamamatsu-shi, Shizuoka-ken 435-8558 (JP)

Inventor: KUSUYAMA, Yutaka,
c/o Hamamatsu Photonics K.K.
Hamamatsu-shi, Shizuoka 435-8558 (JP)

References cited:
DE-A1-19819333
GB-A-2108483
JP-A-57169706
JP-A-2000098191
JP-U-6002311
JP-U-6015016
US-A-5080706
US-A-5293269
US-A-5596671
US-B1-6471372

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).
Description

Field of the Art

[0001] The present invention relates to a method of manufacturing an optical lens that acts on light emitted from a light emitting element.

Background Art

[0002] The methods of manufacture by use of a precision mold and manufacture by application of a silicon semiconductor manufacturing process or LIGA process are known as the conventional methods of manufacturing an optical lens accommodating for a semiconductor laser element as a light emitting element in which a plurality of light emitting components are aligned.


Disclosure of the Invention

[0005] However, since the size of the required optical lens is extremely microscopic in itself, it was extremely difficult to form optical action components that can collimate, converge, or perform optical path conversion of the respective light rays emitted from a semiconductor laser array by such conventional optical lens manufacturing methods.

[0006] An object of the present invention is to provide an optical lens manufacturing method that enable optical action components to be formed readily.

[0007] In order to achieve the above object, an optical lens manufacturing method is provided, as defined in claim 1.

[0008] According to such an optical lens manufacturing method, since the shape of the optical lens, especially the shapes of the optical components can be determined at a stage of the optical lens preform prior to drawing, the processing of the plurality of curved surface parts that are to become the optical components can be performed at an adequately large size. Incident light may be emitted upon changing its angle of divergence or angle of convergence, or to perform optical path conversion of the incident light.

[0009] By cutting the optical lens preform that has been drawn in the drawing step at an inclination angle of 45° with respect to the direction of elongation, an optical lens having a plurality of inclined curved surface parts as optical components can thus be prepared. The resultant optical lens emits light that is rotated with respect to incident light by 90° about the optical axis as the central axis.

Brief Description of the Drawings

[0011] Figs. 1A and 1B are schematic drawings showing the respective steps of an optical lens manufacturing method of an embodiment.

Figs. 2A and 2B are schematic drawings showing the respective steps of the optical lens manufacturing method of the embodiment.

Figs. 3A is a diagram illustrating the actions of an optical lens manufactured by the optical lens manufacturing method according to the embodiment.

Figs 3B and 3C show comparative examples.

Fig. 4A is a sectional view of an optical lens base material according to the above-mentioned embodiment and Fig. 4B is a sectional view of an optical lens formed by drawing the optical lens base material shown in Fig. 4A.

Fig. 5 is an overall view of an optical lens base material according to another embodiment.

Fig. 6A is a diagram showing a step of drawing the optical lens base material shown in Fig. 5 and Fig. 6B is a partially enlarged view of a cut preform obtained by the drawing step illustrated in Fig. 6A.

Fig. 7A is a sectional view of an optical lens base material of another embodiment and Fig. 7B is a sectional view of an optical lens formed by drawing the optical lens base material shown in Fig. 7A.

Fig. 8 is a schematic view showing a drawing step in another embodiment of an optical lens manufacturing method using the optical lens base material shown in Fig. 1A.

Fig. 9 is a schematic view showing a drawing step in another embodiment of an optical lens manufacturing method using the optical lens base material shown in Fig. 5.

Best Mode for Carrying out the Invention

[0012] Embodiments of the present invention shall now be described in detail in accordance to the drawings. In the following description, the same or corresponding parts shall be provided with the same symbols and redundant description shall be omitted.

[0013] Figs. 1A and 1B and Figs. 2A and 2B are schematic views showing the respective steps in an optical lens manufacturing method of an embodiment of the present invention. As shown in Fig. 1A, first, an optical member formed of a light transmitting glass material is prepared, formed as a columnar shape provided with a
first side face 44 and a second side face 46, and this is used as an optical lens base material 40 (optical lens base material preparation step). As the light transmitting glass material, for example, BK7 (made by Schott Corp.); refractive index: 1.52; thermal expansion coefficient: $71 \times 10^{-7}/K$; yield point: 614°C) is used. First side face 44 and second side face 46 are formed parallel to columnar axis direction 20.

In first side face 44 and second side face 46, a plurality of curved surface parts 43, which are parallel to columnar axis direction 20, are formed so as to be in mutual contact. Though in optical lens base material 40 of the present embodiment, these plurality of curved surface parts 43 are formed as convex curved surfaces, they may be formed as concave curved surfaces instead. Each of the plurality of curved surface parts 43 is a cylindrical surface such as a circular cylindrical surface and the plurality of cylindrical surfaces are positioned so as to extend along the same direction: Curved surface parts 43 may also be aspherical surfaces. These plurality of curved surface parts 43 are the parts that function as optical action components that act on incident light or emitted light after a drawing process. In the Figures, these plurality of curved surface parts and optical action components are provided with the same symbols.

At the respective edge parts of optical lens base material 40, which correspond to the respective sides of the plurality of curved surface parts 43, a pair of flange parts 48 are furthermore formed. The respective edge parts of optical lens base material 40 is strongly affected by heating in the drawing step and tend to deform, etc. However, since in optical lens base material 40 of the present embodiment, the pair of flange parts 48 are formed and flange parts 48 receive the influence of heating instead, the influence of heating is avoided more readily at the plurality of curved surface parts 43.

Thus, since with the method of manufacturing an optical lens by the drawing method, the shape of the optical lens to be manufactured, especially the shapes of the optical action components can be formed at the stage of optical lens base material 40, which is adequately large in size (for example, a width and height of 2 to 6cm and a length of 20 to 200cm), these forming processes can be performed in a simple and yet accurate manner.

Here, Japanese Patent Publication No. Hei-7-15521 discloses a method of manufacturing a refractive index distribution type cylindrical lens (Seflo lens) by the drawing method. In this manufacturing method, a high-purity quartz glass rod, in which the fluorine dopant amount increases in stages from the center towards the outer side in the radial direction and the refractive index decreases in stages accordingly, is used as the base material, and unlike the present invention, a base material, in which optical action components are formed in terms of shape, is not used. Though in such a prior-art manufacturing method required, as a base material preparation step, a step of forming a refractive index distribution by doping fluorine by a plasma external attachment method or a method of immersing in a fused salt over long period of time to perform ion exchange, such a step is unnecessary with the present invention. The prior art also differs from the present embodiment in that, in the optical lens that is formed, the light incidence surface and light exit surface does not make use of curved side faces of cylindrical type but make use of the respective end parts.
uflacture is characterized in that the drawn object is cut by a cutter device 37, etc.

[0021] Next as shown in Fig. 2A, the cut preform 50 is cut along the X1-Y1 line and the X2-Y2 line, which are segments that form an angle of 45° with a columnar axis direction 20 (second cutting process), to prepare an optical lens 1, such as shown in Fig. 2B (optical lens preparation step). The interval between these two lines is set to an interval corresponding to the thickness of the light emitting element (semiconductor laser element) to which the prepared optical lens is applied. By increasing the number of segments Xk-Yk (k = 1, ..., n) at which the cut preform 50 is to be cut, a large number of the same optical lenses can be prepared and mass production can thus be accomplished readily. Instead of dividing the cutting process into two parts, optical lens 1 may also be prepared in a single cutting process by cutting the drawn optical lens base material 40 at an angle inclined by 45° with respect to the columnar axis direction 20.

[0022] Due to the characteristics of the drawing process, the cross-sectional shape of optical lens 1, which had been manufactured in the above-described manner, is the same as the cross-sectional shape of optical lens base material 40. In particular, since the shape of the optical action components that were prepared in the initial optical lens base material preparation step is carried over as it is even after the drawing process, there is no need to perform forming at a microscopic element stage after the drawing process. Furthermore, with this embodiment’s method of manufacturing optical lens 1, an optical lens 1, equipped with a plurality of curved surface parts 43, is prepared by a single drawing process, thus enabling the burden in terms of manufacturing to be lightened significantly.

[0023] Fig. 3A is a diagram illustrating the actions of optical lenses manufactured by the optical lens manufacturing method of the present embodiment. Figs. 3B and 3C show comparative examples. In each of these examples, since an optical lens 1, equipped with seven curved surfaces as optical action components 43, is formed, each light emitted, for example, from a semiconductor laser element, in which seven light emitting components are aligned, is subject to collimation, convergence, or optical path conversion and then emitted. The actions of the respective optical lenses 1, 101, and 201 shown here illustrate actions on incident light and do not necessarily illustrate actual application examples.

[0024] In optical lens 1 shown in Fig. 3A, the lights emitted from light emitting components 16 of a semiconductor laser element 15 are collimated or converged in the X-axis direction and then emitted as emitted lights by optical action components 43, which are formed as concave curved surfaces and convex curved surfaces at the light incidence side and light emitting side, respectively. Though light emitted from a light emitting component 16 has an optical section 125 that is long in the X-axis direction and short in the Y-axis direction, as a result of being collimated or converged by optical lens 101, the light is converted to emitted light with an optical section 126 that is approximately the same in length in the X-axis direction as optical section 125 and longer in the Y-axis direction in comparison to optical section 125. Here, since with this embodiment’s optical lens manufacturing method, two rows of curved surface parts can thus be prepared as optical action components 43 at the light incidence side and the light emitting side, a Fourier type or telescope type optical lens can also be formed.

[0025] In optical lens 101 shown in Fig. 3B, the lights emitted from light emitting components 16 of semiconductor laser element 15 are collimated or converged in the X-axis direction and then emitted as emitted lights by optical action components 43, which are formed as convex curved surfaces at the light incidence side. Though light emitted from a light emitting component 16 has an optical section 225 that is long in the X-axis direction and short in the Y-axis direction, as a result of being collimated or converged by optical lens 201, the light is converted to emitted light with an optical section 226 that is approximately the same in length in the X-axis direction as optical section 225 and longer in the Y-axis direction in comparison to optical section 225. In regard to the point that the incident light is collimated or converged in the X-axis direction, the same actions as those of optical lens 101 is provided. With optical lens 201, the light emitting side—maybe subject to a cutting process to newly form optical action components that can perform collimation or convergence in the Y-axis direction to arrange an optical lens that can perform collimation or convergence in both the X-axis direction and the Y-axis direction.

[0026] An optical lens manufacturing method of another embodiment of the present invention shall now be described with reference to Figs. 4 to 7.

[0027] An optical lens manufacturing method of another embodiment of the present invention shall now be described with reference to Figs. 4 to 7.

[0028] Fig. 4A is a sectional view of an optical lens base material of the above-described embodiment, and Fig. 4B is a sectional view of an optical lens formed by drawing the optical lens base material shown in Fig. 4A. The drawing step of the above-described embodiment is carried out at a drawing temperature that is higher than the yield point of optical lens base material 40 and yet at which deformation due to the drawing process is unlikely to occur with the shapes of curved surface parts 43 that are to become the optical action components. Though the drawing temperature is thus set to a low temperature
in comparison to a case where an optical fiber, etc. is drawn, in the present process, the optical lens base material may deform in a manner wherein a flat part formed at a side face, that is, first side face 44 or second side face 46 shrinks inward throughout the drawing process. As shown straightforwardly in Figs. 4A and 4B, optical lens 1 after drawing is deformed in a manner wherein both first side face part 44 and second side face part 46 of optical lens base material 40 are recessed inwards. Such deformation shall be referred to as a "pin-cushion distortion." With an optical lens that is affected by a pin-cushion distortion, it is difficult to accurately collimate or converge the respective lights, emitted by the respective light emitting components of a semiconductor laser element, as designed.

Fig. 5 is an overall view of an optical lens base material of another embodiment. Fig. 6A is a diagram illustrating a step of drawing the optical lens base material shown in Fig. 5, and Fig. 6B is a partially enlarged view of a cut preform obtained by the drawing step shown in Fig. 6A. Fig. 7A is a sectional view of an optical lens base material of another embodiment and Fig. 7B is a sectional view of an optical lens formed by drawing the optical lens base material shown in Fig. 7A. In optical lens base material 140, a first side face 144 and a second side face 146 are formed as convex curved surfaces as a whole. By forming first side face 144 and second side face 146 thus, the protruding parts are recessed inwards after the drawing process, so that an optical lens 501, which is closer to a plane (or planar) and with which the influence of distortion due to drawing is restrained, is formed as shown in Fig. 6B or 7B. Thus with the optical lens manufacturing method of these other embodiments, an optical lens 501 that is equal to or close to the desired shape can be formed.

Though the present invention has been described specifically based on the embodiments, the present invention is not limited to the above-described embodiments in practice of the present invention and includes all changes of the invention within the scope of the Claims, and thus changes concerning the shape, size, positions, arrangement, etc. are possible. For example, though with the above-described embodiments, in the process of drawing optical lens base material 40 as shown in Fig. 1A, the pair of roller contacting surfaces 45 of the drawn optical lens base material are sandwiched by pull rollers 33 as shown in Fig. 1B, it is preferable for first side face 44 and second side face 46 to be sandwiched by pull rollers 33 as shown in Fig. 8. First side face 44 or second side face 46 is wider than roller contacting surface 45. Thus by sandwiching first side face 44 and second side face 46 by pull rollers 33, the drawing process can be carried out in a stable manner. Also, by the same reason, in the process of drawing optical lens base material 140 shown in Fig. 5, it is preferable, instead of sandwiching the pair of roller contacting surfaces 45 of the drawn optical lens base material by pull rollers 33, to sandwich first side face 144 and second side face 146 by pull rollers 33.

Claims

1. An optical lens manufacturing method comprising:

- a manufacturing step of manufacturing an optical lens preform (40) formed of light transmitting material and having an elongate shape, said optical lens preform (40) having a first side face (44) a second side face (46), disposed at the side opposite the first side face (44), and a pair of flange parts (48) extending in the direction of elongation of the preform at the respective sides of the first side face (44) and second side face (46) respectively;

- wherein one or both of said first side face (44) and said second side face (46) has a plurality of curved surface parts (43) for collimation, convergence or optical path conversion of incident light, each curved surface part being formed parallel to the axis of elongation of the preform (40), and aligned so as to be in mutual contact;

- a drawing step of drawing the optical lens preform (40) in said direction of elongation thereof; and

- an optical lens preparation step of preparing an optical lens by cutting said first and second side faces (44, 46) and said flange parts (48) of said optical lens preform (40), which has been drawn in said drawing step, to a desired length, at an angle of inclination of 45° to said direction of elongation.
2. The optical lens manufacturing method as set forth in Claim 1, wherein said optical lens preparation step comprises:

   a first cutting step of preparing a lens intermediate having said first and second side faces (44, 46) and said flange parts (48) by cutting said optical lens preform (40), which has been drawn in said drawing step; and
   a second cutting step of preparing the optical lens by cutting said first and second side faces (44, 46) and said flange parts (48) of said lens intermediate prepared in said first cutting step to the desired length, at the said angle of inclination of 45° to the direction of elongation.

3. The optical manufacturing method as set forth in Claim 1 or Claim 2, wherein the manufacturing step further comprises forming said first side face (44) and said second side face (46) as convex curved surfaces.

4. The optical lens manufacturing method as set forth in Claim 1 or Claim 2, wherein the manufacturing step further comprises forming said plurality of curved surface parts (43) of said optical lens preform (40) as aspherical surfaces.

5. An optical lens manufactured by the optical lens manufacturing method as set forth in any of the preceding claims.

Patentansprüche

1. Verfahren zum Herstellen einer optischen Linse, umfassend:

   einen Herstellungsschritt, eine Vorform (40) einer optischen Linse herzustellen, die aus einem lichtdurchlässigen Material ausgebildet ist und eine längliche Form aufweist, wobei die Vorform (40) der optischen Linse eine erste Seitenfläche (44) und eine zweite Seitenfläche (46) aufweist, die an der Seite gegenüber der ersten Seitenfläche (44) angeordnet ist, und ein Paar von Flansch-Teilen (48), die sich jeweils in die Längsrichtung der Vorform an den jeweiligen Seiten der ersten Seitenfläche (44) und der zweiten Seitenfläche (46) erstrecken;

wobei eine oder beide von der ersten Seitenfläche (44) und der zweiten Seitenfläche (46) eine Mehrzahl von gekrümmten Oberflächen-Teilen (43) zur Kollimation, Konvergenz oder Umwandlung des Strahlengangs des einfallenden Lichts aufweisen, wobei jedes gekrümmte Oberflächenteil parallel zu der Längsachse der Vorform (40) ausgebildet ist und so ausgerichtet ist, um in gegenseitigem Kontakt zu sein; einen Streck-Schritt, die Vorform (40) der optischen Linse in ihre Längsrichtung zu strecken; und einen Anfertigungs-Schritt der optischen Linse, eine optische Linse anzufertigen indem die erste und zweite Seitenfläche (44, 46) und die Flansch-Teile (48) der in dem Streck-Schritt gestreckte Vorform (40) der optischen Linse, auf eine gewünschte Länge mit einem Neigungswinkel von 45° bezüglich der Längsrichtung zugeschnitten werden.

2. Verfahren zum Herstellen einer optischen Linse nach Anspruch 1, wobei der Anfertigungs-Schritt der optischen Linse umfasst:

   einen ersten Schneide-Schritt, ein Linsen-Zwischenprodukt mit der ersten und zweiten Seitenfläche (44, 46) und den Flansch-Teilen (48) anzufertigen, indem die in dem Streck-Schritt gestreckte Vorform (40) der optischen Linse geschnitten wird; und einen zweiten Schneide-Schritt, die optische Linse anzufertigen, indem die erste und zweite Seitenfläche (44, 46) und die Flansch-Teile (48) des in dem ersten Schneide-Schritt angefertigten Linsen-Zwischenprodukts auf die gewünschte Länge in dem Neigungswinkel von 45° bezüglich der Längsrichtung zugeschnitten werden.

3. Verfahren zum Herstellen einer optischen Linse nach Anspruch 1 oder Anspruch 2, wobei der Herstellungsschritt weiter umfasst, die erste Seitenfläche (44) und die zweite Seitenfläche (46) als konvexe, gekrümmte Flächen auszubilden.

4. Verfahren zum Herstellen einer optischen Linse nach Anspruch 1 oder Anspruch 2, wobei der Herstellungsschritt weiter umfasst, die Mehrzahl von gekrümmten Flächen-Teilen (43) der Vorform (40) der optischen Linse als asphärische Flächen auszubilden.

5. Optische Linse, hergestellt nach dem Verfahren zum Herstellen einer optischen Linse nach einem der vorhergehenden Ansprüche.

Revendications

1. Procédé de fabrication d'une lentille optique comprenant :

   une étape de fabrication qui consiste à fabriquer une préforme (40) de lentille optique formée d'un matériau transmettant la lumière et ayant une
forme allongée, ladite préforme (40) de lentille optique ayant une première face latérale (44) et une deuxième face latérale (46), disposée au niveau du côté opposé à la première face latérale (44), et une paire de parties de rebords (48) s’étendant dans la direction d’allongement de la préforme au niveau des côtés respectifs de la première face latérale (44) et de la deuxième face latérale (46) respectivement ;
dans lequel l’une ou les deux parmi ladite première face latérale (44) et ladite deuxième face latérale (46) possède plusieurs parties (43) de surfaces incurvées pour la collimation, la convergence ou la conversion d’un chemin optique d’une lumière incidente, chaque partie de surface incurvée étant formée parallèlement à l’axe d’allongement de la préforme (40) et alignée de sorte se trouver en contact mutuel ;
une étape d’étirage qui consiste à étirer la préforme de lentille optique dans ladite direction d’allongement de celle-ci ; et
une étape de préparation de lentille optique qui consiste à préparer une lentille optique en découpant lesdites première et deuxième faces latérales (44, 46) et lesdites parties de rebords (48) de ladite préforme (40) de lentille optique, qui a été étirée dans ladite étape d’étirage, jusqu’à une longueur désirée, à un angle d’inclinaison de 45° de ladite direction d’allongement.

2. Procédé de fabrication d’une lentille optique selon la revendication 1, dans lequel ladite étape de préparation de lentille optique comprend :

une première étape de découpage qui consiste à préparer une lentille intermédiaire ayant lesdites première et deuxième faces latérales (44, 46) et lesdites parties de rebords (48) en découplant ladite préforme (40) de lentille optique, qui a été étirée dans ladite étape d’étirage ; et
une deuxième étape de découpage qui consiste à préparer ladite lentille optique en découplant lesdites première et deuxième faces latérales (44, 46) et lesdites parties de rebords (48) de ladite lentille intermédiaire préparée dans ladite première étape de découpage jusqu’à la longueur désirée, audit angle d’inclinaison de 45° de la direction d’allongement.

3. Procédé de fabrication d’une lentille optique selon la revendication 1 ou la revendication 2, dans lequel l’étape de fabrication comprend en outre le fait de former ladite pluralité de parties (43) de surfaces incurvées de ladite préforme (40) de lentille optique sous forme de surfaces asphériques.

4. Procédé de fabrication d’une lentille optique selon la revendication 1 ou la revendication 2, dans lequel

5. Lentille optique fabriquée par le procédé de fabrication d’une lentille optique selon l’une quelconque des revendications précédentes.
**Fig. 4A**

**Fig. 4B**
Fig. 6A

Fig. 6B
REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader’s convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2000098191 A [0004]
- JP HEI715521 B [0017]
- GB 2108483 A [0032]