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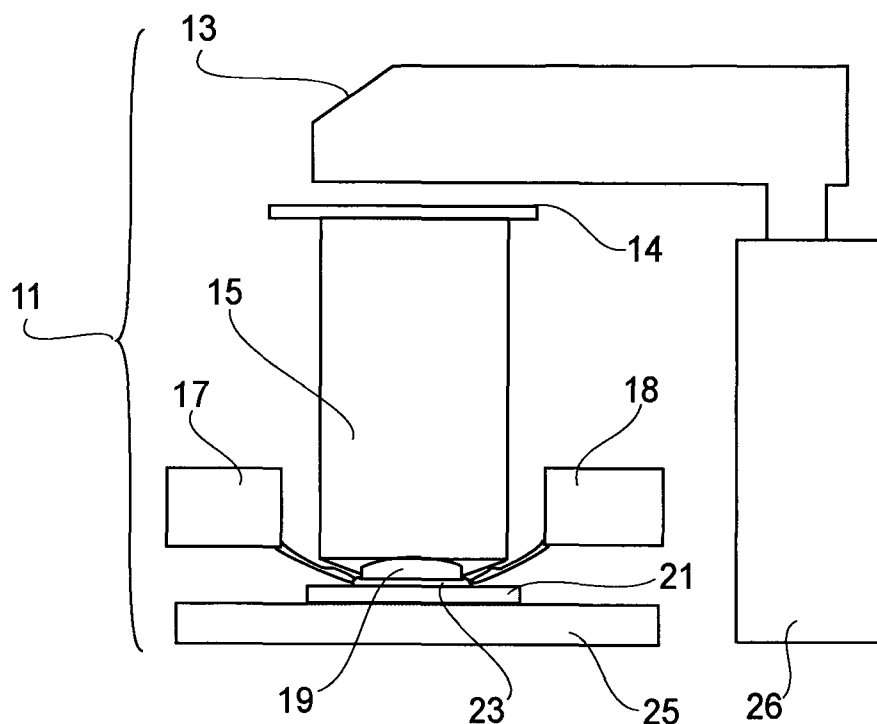
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(54) Title: GLASS COMPOSITION FOR ULTRAVIOLET LIGHT AND OPTICAL DEVICE USING THE SAME



(57) Abstract: A glass composition for ultraviolet light is provided. The glass composition for ultraviolet light contains Lu, Al, and O in an amount of 99.99 weight % or more in total. The glass composition contains Lu in an amount of 24 % or more and 33 % or less in cation percent and Al in an amount of 67 % or more and 76 % or less in cation percent.

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DESCRIPTION

GLASS COMPOSITION FOR ULTRAVIOLET LIGHT AND
OPTICAL DEVICE USING THE SAME

5

[TECHNICAL FIELD]

The present invention relates to a glass composition for ultraviolet light, particularly an oxide glass composition suitable for an optical member
10 used in an optical device.

[BACKGROUND ART]

An optical member is utilized in a wide range of fields such as a camera and a telescope. The
15 optical member can be roughly classified into two types using a crystal as a raw material and glass as the raw material. A crystalline optical member of these optical members is divided in use depending on a crystal system. An optical member used as a lens in an
20 imaging optical system is formed of a cubic crystal. By using an optically isotropic cubic crystal, it is possible to reduce birefringence or the like due to optical anisotropy.

As a glass composition, International
25 Publication No. WO 01/27046 describes glass containing aluminum oxide in an amount of 50 molar % or more and 77 molar % and rare earth oxides in an amount of 25

molar % or more and 50 molar % or less. This publication also discloses lutetium (Lu) as a rare earth element.

With high integration of a semiconductor integrated circuit, demands on ultrafine pattern formation have increasingly grown. A reduced projection exposure device (stepper) of a step-and-repeat type for transferring a minute pattern onto a wafer grows more sophisticated, so that a wavelength of a light source for exposure is shifted to a short wavelength. An optical member which receives attention in optical members for that purpose is a cubic calcium fluoride single crystal having a high transmittance in an ultraviolet region. Further, in recent years, development of optical members using Lu, Al, Mg, and the like higher in refractivity than Si has been tried in order to realize a high refractive index of an optical member for the purpose of providing a higher resolution. For example, development of cubic crystals such as lutetium aluminum garnet single crystal ($\text{Lu}_3\text{Al}_5\text{O}_{12}$), magnesium oxide single crystal (MgO), and magnesium spinel single crystal (MgAl_2O_4) have been actively carried out. Particularly, the lutetium aluminum garnet single crystal has a high refractive index, thus being expected for future development. For example, the lutetium aluminum garnet single crystal has a

refractive index of 2.1 at a wavelength of 193 nm.
Quartz glass has a refractive index of 1.56 at the
wavelength of 193 nm and the calcium fluoride single
crystal has a refractive index of 1.50 at the
5 wavelength of 193 nm.

In the single crystal materials, there arises
a problem of an occurrence of intrinsic birefringence
(IBR). MgO and Al₂O₃ have IBR values of 70 nm/cm
(extrapolated value) and 52 nm/cm (extrapolated value),
10 which are considerably larger than that (3.4 nm/cm) of
CaF₂ (John H. Burnett, Simon G. Kaplan, Eric L.
Shirley, Paul J. Tompkins, and James E. Webb,
"High-Index Materials for 193 nm Immersion Lithography,
Proceedings of the SPIE, Volume 5754, pp. 611 - 621
15 (2005)).

For this reason, development of a material
causing no IBR is required. As an example of
development of a high-refractive index optical member
having a high transmittance in the ultraviolet region,
20 an attempt is made to increase the refractive index by
realizing permanent high density of quartz glass under
application of a pressure (Phys. Chem. Glasses 10, 117
(1969)). However, a change in refractive index by the
pressure application is small, so that the above
25 described high-refractive index optical member has not
been put into practical use.

In summary, it is difficult to increase the

refractive index of the quartz glass, and the crystalline optical member such as the lutetium aluminum garnet single crystal causes the IBR. Further, when the above described optical members are used in an immersion exposure device as an optical device, the optical members have not been sufficient in terms of various characteristics.

[DISCLOSURE OF THE INVENTION]

10 The present invention has been accomplished in view of the above-described circumstances. A principal object of the present invention is to provide a glass composition for ultraviolet light causing no problem of an occurrence of intrinsic birefringence (IBR).

15 Another object of the present invention is to provide a glass composition for ultraviolet light having a high refractive index and a high transmittance and causing less or no IBR and less or no stress birefringence (SBR).

20 A further object of the present invention is to provide a glass composition for ultraviolet light having a resistance to light of a light source and a resistance to a liquid used.

 A still further object of the present invention is to provide optical devices using the above-described glass composition for ultraviolet lights.

According to an aspect of the present invention, there is provided a glass composition for ultraviolet light, comprising:

Lu, Al, and O in an amount of 99.99 weight %
5 or more in total,

wherein the glass composition contains Lu in an amount of 24 % or more and 33 % or less in cation percent and Al in an amount of 67 % or more and 76 % or less in cation percent.

10 According to another aspect of the present invention, there is provided an optical device comprising:

a light source for generating ultraviolet light; and

15 an optical system for irradiating an object with the ultraviolet light from the light source,

wherein the optical system includes an optical member comprising a base material and/or an optical thin film, and

20 wherein the base material and/or the optical thin film comprises a glass composition for ultraviolet light, comprising:

Lu, Al, and O in an amount of 99.99 weight %
or more in total,

25 wherein the glass composition contains Lu in an amount of 24 % or more and 33 % or less in cation percent and Al in an amount of 67 % or more and 76 %

or less in cation percent.

According to a further aspect of the present invention, there is provided an optical device comprising:

5 a light source for generating ultraviolet light; and

 an optical system for irradiating an object with the ultraviolet light from the light source,

 wherein the optical system includes a first
10 optical member and a second optical member having a refractive index larger than that of the first optical member, and

 wherein the second optical member comprises a base material comprising a glass composition for
15 ultraviolet light, comprising:

 Lu, Al, and O in an amount of 99.99 weight % or more in total,

 wherein the glass composition contains Lu in an amount of 24 % or more and 33 % or less in cation
20 percent and Al in an amount of 67 % or more and 76 % or less in cation percent.

 As a result of study on glass materials free from IBR, the present inventors have found that a composition of Lu, Al, and O is not crystallized but
25 is vitrified (changed into an amorphous substance) when the composition of Lu, Au, and O is in a particular range as described above. An oxide of Lu

itself is little vitrified but has a higher refractive index (1.933 at a wavelength of 587.6 nm) compared with a refractive index (1.458 at a wavelength of 587.6 nm) of an oxide of Si. The composition of an Lu oxide and an Al oxide in the particular range is vitrified to constitute a glass composition having a high refractive index.

According to the present invention, with respect to ultraviolet lights having wavelengths of 365 nm, 248 nm, 193 nm, and the like, it is possible to provide a glass composition having solved the above described problem of the occurrence of the IBR (intrinsic birefringence).

Further, according to the present invention, it is possible to provide a glass composition for ultraviolet light having a low SBR (stress birefringence) and resistances to ultraviolet light and a liquid used and provide an optical device using the glass composition for ultraviolet light.

These and other objects, features and advantages of the present invention will become more apparent upon a consideration of the following description of the preferred embodiments of the present invention taken in conjunction with the accompanying drawings.

[BRIEF DESCRIPTION OF THE DRAWINGS]

Figure 1 is a schematic view showing an

optical device according to an embodiment of the present invention.

Figure 2 is a schematic view showing a gas jet levitation device.

5 Figure 3 is a graph showing an X-ray scattering pattern of glass obtained in Example 1 of the present invention.

Figure 4 is a schematic view showing an X-ray diffracting device.

10 Figure 5 is an X-ray photograph showing an X-ray scattering pattern of glass obtained in Example 4 of the present invention.

[BEST MODE FOR CARRYING OUT THE INVENTION]

15 Embodiments for carrying out the present invention are shown below. However, it should be understood that the following description does not limit the scope of the present invention unless otherwise specified.

20 (Embodiment 1)

A glass composition according to Embodiment 1 of the present invention contains Lu, Al, and O in an amount of 99.99 weight (wt.) % in total and contains Lu in an amount of 24 % or more and 33 % or less in
25 cation percent and Al in an amount of 67 % or more and 76 % or less in cation percent.

In an oxide glass composition, when a main

component of the glass is consisting of Lu, Al, and O,
a vitrifiable range is determined by contents thereof.
Vitrification is performed by a method in which melt
of a target composition is prepared and abruptly
5 cooled or by a vapor phase synthesizing method such as
chemical vapor deposition (CVD) or the like.

The glass composition of this embodiment
contains Lu, Al, and O in the total amount of 99.99
wt. %, preferably in a total amount unlimitedly closer
10 to 100 wt. %. As described above, this glass
composition contains Lu in the amount of 28 % or more
and 32 % or less in cation percent and Al in the
amount of 68 % or more and 72 % or less in cation
percent. When the contents of Lu and Al are within
15 these ranges, the composition is changed into an
amorphous substance, thus being preferable since the
problem of the intrinsic birefringence (IBR) does not
arise.

Herein, the cation percent of Lu means a ratio
20 of the ion number of a cation of Lu to the sum of the
ion number of cations of Lu and Al. The cation percent
of Al means a ratio of the ion number of the cation of
Lu to the sum of the ion number of the cations of Lu
and Al.

25 The glass composition of Lu, Al, and O
described above may preferably be consisting of Lu_2O_3
and Al_2O_3 . In this case, the contents of Lu_2O_3 and

Al₂O₃ may preferably be represented by Lu in the amount of 24 % or more and 33 % or less in cation percent and Al in the amount of 67 % or more and 76 % or less in cation percent.

5 In the glass composition, an impurity impairs vitrification and generates a defective portion in many cases, so that the content thereof may appropriately be controlled in an amount of 100 ppm or less. On the other hand, boron (B) may be added to the
10 glass composition as desired.

The above-described glass composition itself can be utilized as not only a base material (glass material) of a lens but also a sputtering target to be used for forming an optical thin film.

15 These lens and optical thin film may suitably be used as an optical member through which ultraviolet light with a wavelength of 365 nm or less, preferably 248 nm or less, further preferably 193 nm or less, passes.

20 (Embodiment 2)

In an exposure device as an optical device according to Embodiment 2 of the present invention, a light source for generating light in a vacuum ultraviolet region with a wavelength of 200 nm or less
25 (e.g., ArF excimer laser; oscillation wavelength = 193 nm) is used. This is because a resolution line width is smaller with a smaller exposure wavelength and a

larger numerical aperture, thus improving a resolution.

In this embodiment, a liquid is filled between an exposure substrate and a final lens of the exposure device to substantially decrease a wavelength of light at the surface of the exposure substrate, thus
5 constituting an immersion exposure device for improving a resolution.

The immersion exposure device at least includes the light source, an illumination optical
10 system, an optical mask (reticle), a projection optical system, and a supply/recovery device for the liquid. Exposure to light is performed in a state in which the liquid is filled between a lens (final lens) provided at an end of the projection optical system
15 close to the exposure substrate and the exposure substrate provided with a photosensitive film.

The final lens of such an immersion exposure device is required to have a high refractive index and a high transmittance at a wavelength of light from the
20 light source. Further, the final lens is also required to cause less or no birefringence (IBR and SBR). In addition, the final lens is required to have resistances to the light from the light source and the liquid used. For these increases, in Embodiment 2, the
25 lens comprising the glass composition described in Embodiment 1 is used as the final lens. As lenses other than the final lens, lenses of quartz glass are

used.

On these lenses, an optical thin film for preventing reflection is formed as desired.

Figure 1 is a schematic view of the immersion
5 exposure device.

Referring to Figure 1, an immersion exposure device 11 includes an illumination optical system 13, an optical mask (reticle) 14, a projection optical system 15 separated from the illumination optical
10 system 13 by the mask 14, liquid supply/recovery devices 17 and 18, a stage 25 capable of moving an exposure substrate, and a laser light source 26.

The projection optical system 15 includes lenses formed of quartz glass as a first optical
15 member having a relatively low refractive index and a final lens 19 as a second optical member having a relatively high refractive index. The projection optical system 15 effects exposure by irradiating an exposure substrate 21 provided with a photosensitive
20 film as an objected (to be exposed) with ultraviolet light in a state in which a liquid 23 is filled between the final lens 19 and the exposure substrate 21 provided with the photosensitive film.

By this exposure, a pattern of the optical
25 mask (reticle) 14 is reduced in size and can be transferred onto the exposure substrate 21. In Figure 4, the liquid 23 is held only between the final lens

19 and the exposure substrate 21 but is not limited thereto. For example, the entire substrate 21 may also be immersed in the liquid 23. As the liquid 23, it is possible to use pure water having a refractive index
5 (at 20 °C) of 1.44 with respect to a wavelength of 193 nm and a fluorine-containing organic solvent.

The immersion exposure device of Embodiment 2 may preferably include a laser light source with a wavelength of 200 nm as the light source. More
10 specifically, the immersion exposure device includes an ArF excimer laser oscillator or an F2 excimer laser oscillator. By using such a laser light source with a short wavelength as the light source, a resolution of the resultant exposure device can be improved.

15 The optical member according to this embodiment is suitably used as an optical member for an exposure device transparent to vacuum ultraviolet light with a wavelength of 193 nm.

(Embodiment 3)

20 An optical device according to Embodiment 3 of the present invention includes a light source for generating ultraviolet light and an optical system for irradiating an object with the ultraviolet light from the light source. The optical system includes an
25 optical member comprising a base material and/or an optical thin film. The base material and/or the optical thin film comprises a glass composition for

ultraviolet light, comprising: Lu, Al, and O in an amount of 99.99 weight % or more in total, wherein the glass composition contains Lu in an amount of 24 % or more and 33 % or less in cation percent and Al in an amount of 67 % or more and 76 % or less in cation percent.

In other words, a lens is prepared by using the above-described glass composition for ultraviolet light itself as the base material.

Alternatively, an optical member lens such as a lens or a mirror is prepared by forming an optical thin film with a high refractive index on a surface of the base material such as a silicon wafer or quartz glass through sputtering using the above-described glass composition for ultraviolet light as a target. The optical thin film is characterized by containing Lu, Al, and O in an amount of 99.99 weight % or more in total and containing Lu in an amount of 24 % or more and 33 % or less in cation percent and Al in an amount of 67 % or more and 76 % or less in cation percent.

The optical member according to this embodiment is suitably used as an optical member for an optical device transparent to ultraviolet light with a wavelength of 365 nm or less, preferably 248 nm or less, further preferably 193 nm or less.

The present invention is described more

specifically based on Examples below.

(Example 1)

As starting materials for synthesizing glass, Lu_2O_3 (purity: 99.99 wt. %) and Al_2O_3 (purity: 99.998 wt. %) were used. These starting materials were weighed and sufficiently mixed in a mortar in a weight ratio ($\text{Lu}_2\text{O}_3:\text{Al}_2\text{O}_3$) of 1.92:1 so that Lu_2O_3 and Al_2O_3 contain Lu in an amount of 33 % in cation percent and Al in an amount of 67 % in cation percent, respectively. Thereafter, about 100 mg of the mixture was partly melted by irradiation with a carbon dioxide gas laser and an output of the laser was lowered, so that a spherical polycrystalline aggregate was prepared.

This polycrystalline aggregate as a sample 1 was set on a copper nozzle 2 of the gas jet levitation device shown in Figure 2 and was then heated again by the carbon dioxide gas laser 4 in a floating state created by using Ar gas 3, thus being completely melted. In that state, the output of the laser was cut off to abruptly cool the sample 1, so that a transparent spherical material was obtained. This process was monitored by a radiation pyrometer with respect to a temperature but an exothermic reaction due to crystallization was not observed.

This transparent spherical material was examined with respect to the presence or absence of a

crystal by an X-ray diffraction method, Figure 3 shows an X-ray scattering intensity curve of the transparent spherical material. In Figure 3, an abscissa represents $Q (= 4 \pi \sin \theta / \lambda)$ and an ordinate represents a scattering intensity $I(Q)$. As a light source, an X-ray monochromatized to 113.4 KeV was used. Three or four spherical samples (diameter: 2 - 3 mm) were placed in a capillary of SiO_2 glass or interposed between kapton films and scattering X-ray from the samples was measured by a Ge solid detector. From the scattering pattern shown in Figure 3, a diffraction pattern showing crystallinity was not found and the scattering pattern was a halo pattern characterizing glass, so that it was confirmed that the transparent spherical material in this example was a glass (amorphous material).

(Example 2)

As starting materials for synthesizing glass, Lu_2O_3 (purity: 99.99 wt. %) and Al_2O_3 (purity: 99.998 wt. %) were used. These starting materials were weighed and sufficiently mixed in a mortar in a weight ratio ($\text{Lu}_2\text{O}_3:\text{Al}_2\text{O}_3$) of 1.67:1 so that Lu_2O_3 and Al_2O_3 contain Lu in an amount of 30 % in cation percent and Al in an amount of 70 % in cation percent, respectively. Thereafter, about 100 mg of the mixture was partly melted by irradiation with a carbon dioxide gas laser and an output of the laser was lowered, so

that a spherical polycrystalline aggregate was prepared.

This polycrystalline aggregate as a sample 1 was set on a copper nozzle 2 of the gas jet levitation device shown in Figure 2 and was then heated again by the carbon dioxide gas laser 4 in a floating state created by using Ar gas 3, thus being completely melted. In that state, the output of the laser was cut off to abruptly cool the sample, so that it was possible to obtain a transparent spherical glass.

(Example 3)

As starting materials for synthesizing glass, Lu_2O_3 (purity: 99.99 wt. %) and Al_2O_3 (purity: 99.998 wt. %) were used. These starting materials were weighed and sufficiently mixed in a mortar in a weight ratio ($\text{Lu}_2\text{O}_3:\text{Al}_2\text{O}_3$) of 1.23:1 so that Lu_2O_3 and Al_2O_3 contain Lu in an amount of 24 % in cation percent and Al in an amount of 76 % in cation percent, respectively. Thereafter, about 100 mg of the mixture was partly melted by irradiation with a carbon dioxide gas laser and an output of the laser was lowered, so that a spherical polycrystalline aggregate was prepared.

This polycrystalline aggregate as a sample 1 was set on a copper nozzle 2 of the gas jet levitation device shown in Figure 2 and was then heated again by the carbon dioxide gas laser 4 in a floating state

created by using Ar gas 3, thus being completely melted. In that state, the output of the laser was cut off to abruptly cool the sample, so that it was possible to obtain a transparent spherical glass.

5 (Example 4)

As starting materials for synthesizing glass, Lu_2O_3 (purity: 99.99 wt. %) and Al_2O_3 (purity: 99.998 wt. %) were used. These starting materials were weighed and sufficiently mixed in a mortar in a weight
10 ratio ($\text{Lu}_2\text{O}_3:\text{Al}_2\text{O}_3$) of 1.44:1 so that Lu_2O_3 and Al_2O_3 contain Lu in an amount of 27 % in cation percent and Al in an amount of 73 % in cation percent, respectively. Thereafter, about 100 mg of the mixture was partly melted by irradiation with a carbon dioxide
15 gas laser and an output of the laser was lowered, so that a spherical polycrystalline aggregate was prepared.

This polycrystalline aggregate as a sample 1 was set on a copper nozzle 2 of the gas jet levitation
20 device shown in Figure 2 and was then heated again by the carbon dioxide gas laser 4 in a floating state created by using Ar gas 3, thus being completely melted. In that state, the output of the laser was cut off to abruptly cool the sample, so that it was
25 possible to obtain a transparent spherical material.

This transparent spherical material was examined with respect to the presence or absence of a

crystal by an X-ray diffraction method. Figure 4 shows a layout diagram of an X-ray diffracting device. In Figure 4, as a radiation source of an X-ray generating device 5, MO was used and X-ray was monochromatized by a graphite monochromator 6. Thereafter, the X-ray was changed to a beam of 0.8 mm in diameter by a collimator 7 and entered a sample 8. Scattering X-ray from the samples was recorded by an imaging plate 9. In front of the imaging plate 9, a beam stopper 10 is disposed. The resultant scattering pattern is shown in Figure 5. As understood from the scattering pattern shown in Figure 5, a diffraction pattern showing crystallinity was not found and scattering from glass was confirmed, so that it was confirmed that the transparent spherical material in this example was a glass (amorphous material).

(Comparative Example 1)

As starting materials for synthesizing glass, Lu_2O_3 (purity: 99.99 wt. %) and Al_2O_3 (purity: 99.998 wt. %) were used. These starting materials were weighed and sufficiently mixed in a mortar in a weight ratio ($\text{Lu}_2\text{O}_3:\text{Al}_2\text{O}_3$) of 1.10:1 so that Lu_2O_3 and Al_2O_3 contain Lu in an amount of 22 % in cation percent and Al in an amount of 78 % in cation percent, respectively. Thereafter, about 100 mg of the mixture was partly melted by irradiation with a carbon dioxide gas laser and an output of the laser was lowered, so

that a spherical polycrystalline aggregate was prepared.

This polycrystalline aggregate as a sample 1 was set on a copper nozzle 2 of the gas jet levitation device shown in Figure 2 and was then heated again by the carbon dioxide gas laser 4 in a floating state created by using Ar gas 3, thus being completely melted. In that state, the output of the laser was cut off to abruptly cool the sample, so that it was found that the resultant sample became white and turbid, thus being in a polycrystalline state.

(Comparative Example 2)

As starting materials for synthesizing glass, Lu_2O_3 (purity: 99.99 wt. %) and Al_2O_3 (purity: 99.998 wt. %) were used. These starting materials were weighed and sufficiently mixed in a mortar in a weight ratio ($\text{Lu}_2\text{O}_3:\text{Al}_2\text{O}_3$) of 2.10:1 so that Lu_2O_3 and Al_2O_3 contain Lu in an amount of 35 % in cation percent and Al in an amount of 65 % in cation percent, respectively. Thereafter, about 100 mg of the mixture was partly melted by irradiation with a carbon dioxide gas laser and an output of the laser was lowered, so that a spherical polycrystalline aggregate was prepared.

This polycrystalline aggregate as a sample 1 was set on a copper nozzle 2 of the gas jet levitation device shown in Figure 2 and was then heated again by

the carbon dioxide gas laser 4 in a floating state created by using Ar gas 3, thus being completely melted. In that state, the output of the laser was cut off to abruptly cool the sample, so that it was found
 5 that the resultant sample became white and turbid, thus being in a polycrystalline state.

Results of Examples 1 to 4 and Comparative Examples 1 and 2 described above are shown in Table 1.

10

Table 1

Ex.No.	Lu (%) ^{*1}	Al (%) ^{*2}	Vitrification
Comp.Ex. 1	22	78	Not vitrified
15 Ex. 3	24	76	Vitrified
Ex. 1	27	73	Vitrified
20 Ex. 4	30	70	Vitrified
Ex. 2	33	67	Vitrified
Comp.Ex. 2	35	65	Not Vitrified
25			

*1: Cation percent of Lu for Lu₂O₃

*2: Cation percent of Al for Al₂O₃

[INDUSTRIAL APPLICABILITY]

The glass composition for ultraviolet light according to the present invention is capable of suppressing an adverse influence due to intrinsic
5 birefringence (IBR), so that the glass composition can be utilized as not only a lens for visible light but also a lens for ultraviolet light.

While the invention has been described with reference to the structures disclosed herein, it is
10 not confined to the details set forth and this application is intended to cover such modifications or changes as may come within the purpose of the improvements or the scope of the following claims.

CLAIMS

1. A glass composition for ultraviolet light, comprising:

5 Lu, Al, and O in an amount of 99.99 weight % or more in total,

 wherein said glass composition contains Lu in an amount of 24 % or more and 33 % or less in cation percent and Al in an amount of 67 % or more and 76 %
10 or less in cation percent.

2. An optical device comprising:

 a light source for generating ultraviolet light; and

15 an optical system for irradiating an object with the ultraviolet light from said light source,

 wherein said optical system includes an optical member comprising a base material and/or an optical thin film, and

20 wherein the base material and/or the optical thin film comprises a glass composition for ultraviolet light, comprising:

 Lu, Al, and O in an amount of 99.99 weight % or more in total,

25 wherein said glass composition contains Lu in an amount of 24 % or more and 33 % or less in cation percent and Al in an amount of 67 % or more and 76 %

or less in cation percent.

3. An optical device comprising:

a light source for generating ultraviolet

5 light; and

an optical system for irradiating an object
with the ultraviolet light from said light source,

wherein said optical system includes a first
optical member and a second optical member having a
10 refractive index larger than that of the first optical
member, and

wherein the second optical member comprises a
base material comprising a glass composition for
ultraviolet light, comprising:

15 Lu, Al, and O in an amount of 99.99 weight %
or more in total,

wherein said glass composition contains Lu in
an amount of 24 % or more and 33 % or less in cation
percent and Al in an amount of 67 % or more and 76 %
20 or less in cation percent.

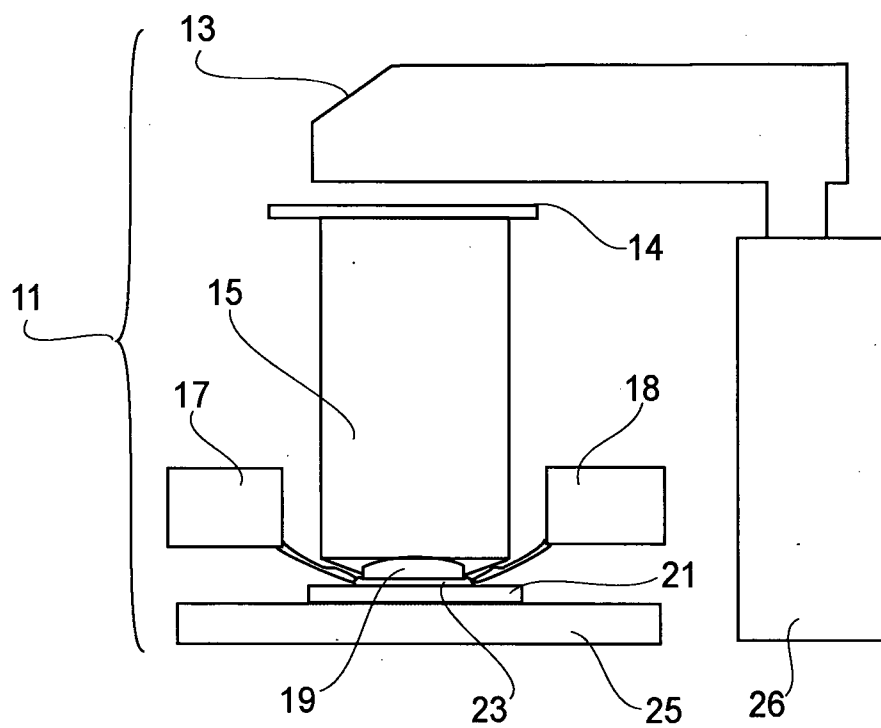
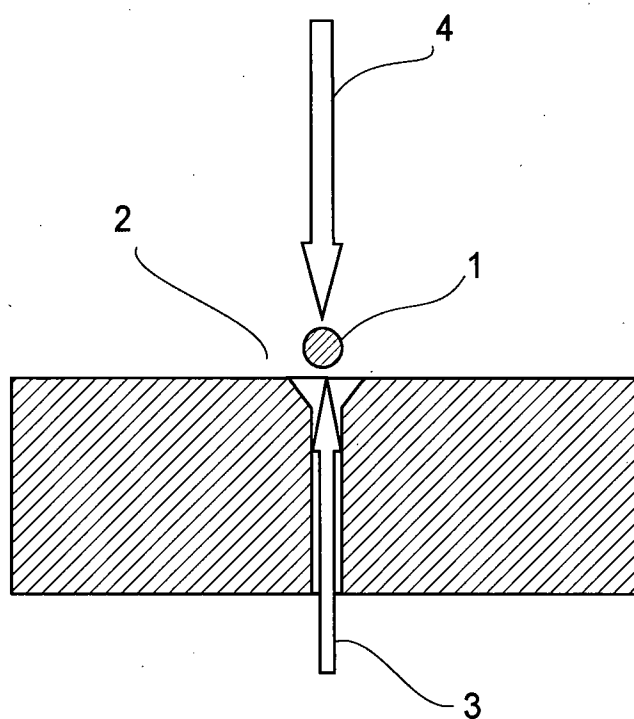
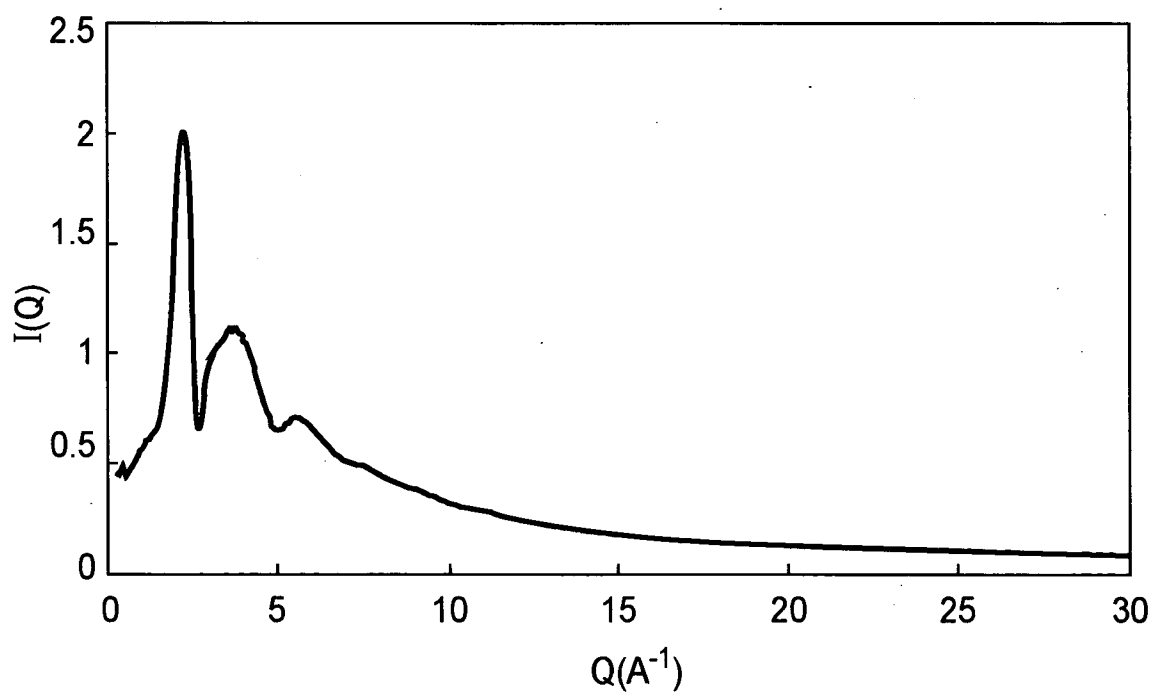


FIG. 1

2/3

**FIG.2****FIG.3**

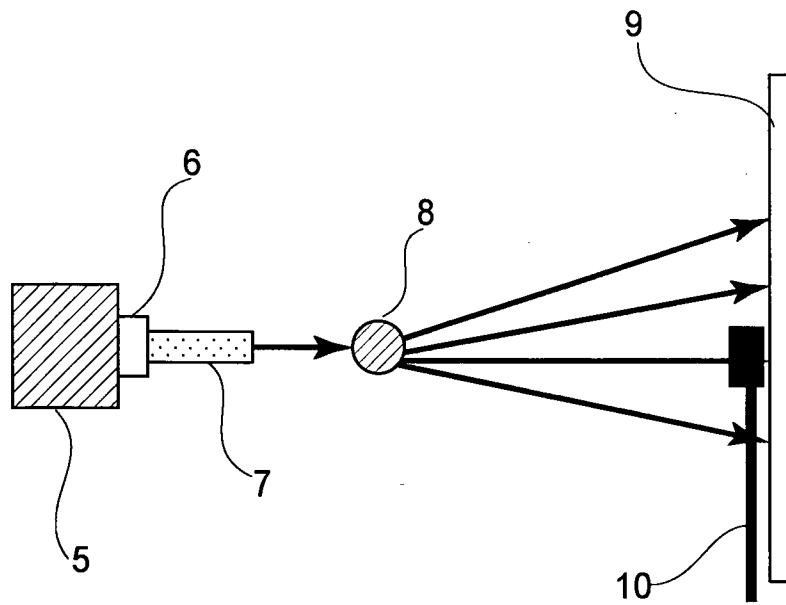


FIG. 4

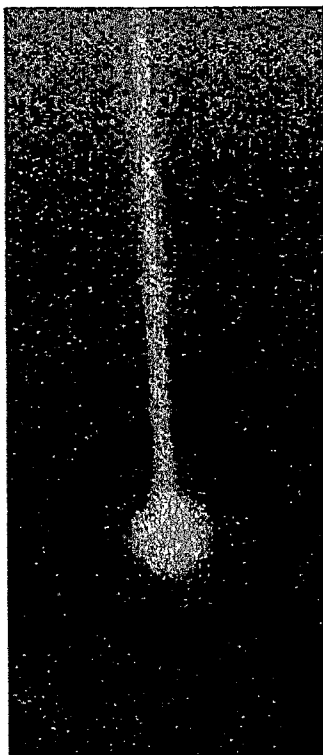


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2007/072989

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. C03C3/095 (2006.01) i, G02B1/02 (2006.01) i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. C03C1/00-14/00, G02B1/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
 Published unexamined utility model applications of Japan 1971-2008
 Registered utility model specifications of Japan 1996-2008
 Published registered utility model applications of Japan 1994-2008

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

INTERGLAD

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2001/027046 A1 (CONTAINERLESS RESEARCH, INC.)	1
Y	2001.04.19, claim; page 12, line 12 to page 13, line 7 & US 6482758 B1	2, 3
Y	WO 2006/121009 A1 (NIKON CORPORATION) 2006.11.16, paragraph 0087 (Family: none)	2, 3

☐ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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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

14.02.2008

Date of mailing of the international search report

26.02.2008

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