progression suppression effect using a monochromatic aberration of a pencil that is a bundle of rays passing through the ophthalmological lens and passing through a pupil,

the ophthalmological lens including a wavelength filter for attenuating light of a long wavelength longer than a set dominant wavelength.

[0006] A second aspect of the present disclosure is an aspect according to the first aspect, including:

a predetermined location AP; and a base portion BP that is a portion adjacent to the predetermined location AP,

in which light is focused on a retina and light is focused on a location other than the retina due to the predetermined location AP and the base portion BP.

[0007] A third aspect of the present disclosure is an aspect according to the second aspect, in which

the predetermined location AP satisfies at least one of the following.

(1) The predetermined location AP includes a convex portion region that protrudes from a base portion BP of at least one of an eyeball-side surface and an object-side surface of the ophthalmological lens so as to focus a portion of the pencil on the overfocus side relative to the retina.

(2) The predetermined location AP includes a diffraction structure on at least one of the eyeball-side surface and the object-side surface of the ophthalmological lens so as to focus a portion of the pencil on the overfocus side relative to the retina using a diffractive action of the predetermined location AP.

(3) The predetermined location AP is provided on at least one of the eyeball-side surface and the object-side surface of the ophthalmological lens, and includes a different refractive index material region having a refractive

index different from the refractive index of the base portion BP, so as to focus a portion of the pencil on the overfocus side relative to the retina using reciprocal actions of the predetermined location AP and the base portion BP.

[0008] A fourth aspect of the present disclosure is an aspect according to the second or third aspect, in which

a high-order monochromatic aberration of a fourth order or higher is added to a pencil passing through a range with a diameter of 4 mm that includes both the predetermined location AP and the base portion BP.

[0009] A fifth aspect of the present disclosure is an aspect according to the third aspect, in which

the wavelength filter is provided on at least one of the convex portion region, the diffraction structure, and the different refractive index material region.

[0010] A sixth aspect of the present disclosure is an aspect according to any one of the first to fifth aspects, in which

the set dominant wavelength is one value in a range of 500 to 585 nm.

[0011] A seventh aspect of the present disclosure is an aspect according to any one of the first to sixth aspects, in which

the set dominant wavelength is one value in a range of 532 to 575 nm.

[0012] An eighth aspect of the present disclosure is an aspect according to any one of the first to seventh aspects, in which

the set dominant wavelength is one value in a range of 564 to 570 nm.

[0013] A ninth aspect of the present disclosure is

an ophthalmological lens configured to provide a near-sightedness progression suppression effect using a monochromatic aberration of a pencil that is a bundle of rays passing through the ophthalmological lens and passing through a pupil, the ophthalmological lens having a spectral transmittance set such that an average value of a defocus amount (Diopter)

[0037] "Attenuating light of a long wavelength longer than the set dominant wavelength" means lowering the average transmittance of light of a wavelength (e.g., under optimal conditions, a long wavelength that exceeds 564 to 570 nm) that is longer than the above-described dominant wavelength. The wavelength filter may be implemented in a variety of different forms to have this property of attenuation. Although there is also no particular limitation to the upper limit of the long wavelength, the upper limit may be 780 nm or 830 nm.

[0038] Note that it can also be said that attenuating the light of a long wavelength using the wavelength filter is controlling the spectral transmittance indicating the transmittance of each wavelength.

[0039] That is, with the ophthalmological lens according to an aspect of the present disclosure, the near-sightedness suppression effect is provided by focusing a portion of the pencil that enters the ophthalmological lens on the overfocus side relative to the retina using a monochromatic aberration. In addition to this, the component of the light that is focused on the underfocus side relative to the retina among the components of the light that occur due to a longitudinal chromatic aberration can be reduced. As a result, the effect of suppressing the progression of near-sightedness is not impaired. Note that "focusing" is not necessarily limited to focusing in a narrow sense, in which substantially non-aberrant light is collected at one point, and also encompasses focusing in a broad sense, such as a position at which a concentration of flare light in a diffractive lens is high.

Details of Eyeglass Lens According to One Aspect of the Present Disclosure

[0040] Hereinafter, further specific examples, preferable examples, and modified examples of an aspect of the present disclosure will be described.

[0053] That is, combining the following two configurations is one feature of an aspect of the present disclosure:

- Defocusing toward the overfocus side relative to the retina is caused by a predetermined location AP provided on the ophthalmological lens, and
- The light that would have been focused toward the underfocus side relative to the retina due to a longitudinal chromatic aberration (i.e., the light that inhibits the near-sightedness progression suppression effect) is attenuated.

[0054] It may be desired for the predetermined location AP to satisfy at least one of the following three conditions.

(1) The predetermined location AP includes a convex portion region that protrudes from a base portion BP of at least one of the eyeball-side surface and the object-side surface of the ophthalmological lens so as to focus a portion of the pencil on the overfocus side relative to the retina.

(2) The predetermined location AP includes a diffraction structure on at least one of the eyeball-side surface and the object-side surface of the ophthalmological lens so as to focus a portion of the pencil toward the overfocus side relative to the retina using a diffractive action of the predetermined location AP.

(3) The predetermined location AP is provided on at least one of the eyeball-side surface and the object-side surface of the ophthalmological lens, and includes a different refractive index material region having a refractive index different from the refractive index of the base portion BP, so as to focus a portion of the pencil on the overfocus side relative to the retina using reciprocal actions of the predetermined location AP and the base portion BP.

[0055] Condition (1) encompasses being provided at the predetermined location AP such that multiple (e.g., 100 or more, preferably 500 or more, and more preferably 1000 or more) convex portion regions are surrounded by the base portion BP (e.g., similar to an arrangement of minute convex

portions provided on an eyeglass lens as described in US 2017/131567A). This aspect is mainly described in the present specification.

[0056] On the other hand, a case in which one, two, or three convex portion regions (also includes a small lens of a bifocal lens or the like) are provided as the predetermined locations AP is also included in condition (1). A case in which the convex portion region has a circular ring shape with respect to the lens center is also included. The lens center in this context indicates the geometric center, the centering center, or the optical center of the eyeglass lens. In the present aspect, a case of using the centering center is illustrated as an example.

[0057] Condition (2) includes a case in which the region (phase diffraction structure) in which the one cross-section of the lens is a saw blade shape or a convexo-concave shape is provided at the predetermined location AP, as in a diffraction lens or a Fresnel lens. Also, the convexo-concave shape may also be a periodic structure, or a non-periodic structure such as surface roughness formed in embossing. Furthermore, it is also possible to use a region in which a pattern is formed in a circular ring shape that surrounds the lens center. Note that condition (2) also includes a case in which one, two, or three convexo-concave regions are provided as the predetermined location AP. Focusing performed using the diffractive action can be performed using the above-described phase diffraction structure, as well as an amplitude diffraction structure that causes a diffractive action using the difference in transmittance between a light-blocking portion and a transmissive portion.

[0058] In conditions (1) and (2) above, a high-order monochromatic aberration of a fourth order or higher is added to the light emitted from the ophthalmological lens due to the “shape” of a cross section of the ophthalmological lens or the difference in the transmittance of the

definition above. Note that other than the above-described method, a wave motion optical method may also be used.

Method for Manufacturing Eyeglass Lens

[0110] A specific example of a method for manufacturing the eyeglass lens 1 will be described.

[0111] In the manufacture of the eyeglass lens 1, first, the lens base material 2 is molded using a known molding method, such as cast polymerization. For example, by using a mold having a molding surface equipped with multiple concave portions and performing molding through cast polymerization, the lens base material 2 having the convex portion regions 6 on at least one surface is obtained.

Then, when the lens base material 2 is obtained, next, the wavelength filter 7 is formed on the surface of the lens base material 2. The wavelength filter 7 can be formed by using the method of immersing the lens base material 2 in the wavelength filter chemical solution, or the like.

Next, the hard coat film 8 is deposited on the surface of the lens base material 2. The hard coat film 8 can be formed by using a method of immersing the lens base material 2 in a hard coat solution, spin coating, or the like.

When the hard coat film 8 is deposited, a reflection prevention film 10 is further deposited on the surface of the hard coat film 8. The hard coat film 8 can be formed by depositing a reflection prevention agent through vacuum deposition. The reflection prevention film can also further be implemented as a wavelength filter.

The eyeglass lens 1 which has an object-side surface 3 with multiple convex portion regions 6 that protrude toward the object can be obtained using the manufacturing method of this procedure.

Aspects of Regions Other Than Convex Portion Region, Convexo-concave Region, and Different Refractive Index Material Region

[0112] For example, a configuration is given in which multiple holes having a circular shape in a plan view are provided as a dot pattern in a film (e.g., a light blocking film; here, a Cr film is illustrated as an example) formed on the hard coat film, or on the lens base material on which the convex portion region, the convexo-concave region, the different refractive index material region, and the like have not been provided, or the like.

[0113] Fig. 5 shows a schematic front view and a partial enlarged view of an eyeglass lens of a modified example that includes a light blocking film (e.g., a Cr film) provided with holes in the form of a dot pattern.

[0114] Note that it is sufficient to use a known method as the method for providing the holes, and an example thereof is a method in which a chemical agent is applied in a dot pattern to a surface of the lens base material, a hard coat film on the surface, or the like, and the chemical agent is allowed to dry, whereafter a light blocking film is deposited so as to cover the dried chemical agent in the dot pattern, and thereafter the light blocking of the chemical agent is removed by removing the chemical agent, and as a result, holes are formed in a dot pattern in the light blocking film.

[0115] The near-sightedness progression suppression effect is provided also by this eyeglass lens. Note that the eyeglass lens is provided with the near-sightedness progression suppression effect because of the effect of diffracting the light by the dot pattern formed in the light blocking film (amplitude diffraction structure).

[0116] For example, diffracted light that is not of a zero-th order is collected at locations other than the retina due to the light diffraction effect. In addition, light on the underfocus side is attenuated by providing a

wavelength filter, which is one of the features of an aspect of the present disclosure, on the ophthalmological lens.

[0117] Accordingly, the amount of light that is defocused at each wavelength can be controlled, and the effect of suppressing the progression of near-sightedness (or of far-sightedness, in such an embodiment as described herein) is prevented from being inhibited.

[0118] Note that the diameter 2r of the holes and the pattern width d of the dot pattern shown in Fig. 5 are not particularly limited, as long as their dimensions are such that the above-described light diffraction effect is exhibited.

[0119] In view of the above description, the predetermined location AP and the base portion BP may be described as follows in order to encompass a case in which a portion at which a film is present is set as the base portion BP and to encompass content described before the item of the present modified example.

"The ophthalmological lens described above, including: a predetermined location AP; and a base portion BP that is a portion adjacent to the predetermined location AP,

in which light is focused on a retina and light is focused on a location other than the retina due to the predetermined location AP and the base portion BP."

Note that a film may also be provided in a dot pattern, conversely to providing holes in a dot pattern. That is, conversely, the portions at which the film is present may be set as the predetermined locations AP, and the portion at which the holes are not provided may be set as the base portion BP. The above-described expression is an expression that can correspond also to another modified example.

[0120] That is, the ophthalmological lens of the present modified

example provides a diffraction phenomenon due to the difference in the states of the films. For this reason, not only a certain region (e.g., regions of holes) contributes to splitting the light, but the film that is formed, and consequently, the overall structure of the ophthalmological lens contribute to splitting the light.

[0121] Note that the "difference in the states of the films" in this context includes any of the following: a case in which holes are provided in a light blocking film as in the preceding example; a case in which, conversely, a light blocking film is provided at only locations corresponding to the holes; a case in which a multi-layer film is provided and holes are provided in only a predetermined surface film; and a case in which, conversely, many multi-layer films are set only at predetermined locations.

[0122] Ultimately, there is no limitation to an aspect such as the present modified example, the convex portion region, the convexo-concave region, or the different refractive index material region, as long as the ophthalmological lens focuses light on the retina and on locations other than the retina using the predetermined location AP and the base portion BP.

Exhibiting Far-sightedness Progression Suppression Effect

[0123] In the case of an aspect in which the far-sightedness progression suppression effect is exhibited, a corresponding description of each of a number of examples is obtained by replacing "overfocus side" with "underfocus side", replacing "long wavelength" with "short wavelength", and replacing "a long wavelength that exceeds 534 nm" with "a short wavelength that falls below 534 nm" in the description of any of the examples relating to near-sightedness progression suppression above.

An aspect in which this far-sightedness progression suppression effect is exhibited is as follows.

CLAIMS

[Claim 1] An ophthalmological lens suppressing progression of near-sightedness using a monochromatic aberration of a pencil that is a bundle of rays passing through the ophthalmological lens and passing through a pupil, the ophthalmological lens comprising:

a wavelength filter for attenuating light of a long wavelength longer than a dominant wavelength in a range of 500 to 585 nm;

a predetermined location (AP);

a base portion (BP) that is a portion adjacent to the predetermined location (AP);

a passing region through which the pencil travels,

wherein light is focused on a retina as well as a location other than the retina due to the predetermined location (AP) and the base portion (BP),

wherein the predetermined location (AP) satisfies at least one of conditions (1) to (3) as follows:

(1) the predetermined location (AP) includes a convex portion region that protrudes from the base portion (BP) of at least one of an eyeball-side surface and an object-side surface of the ophthalmological lens so as to focus a portion of the pencil on an overfocus side relative to the retina, and more than one of the predetermined locations (AP) are surrounded by the base portion (BP),

(2) the predetermined location (AP) includes a refraction structure on at least one of the eyeball-side surface and the object-side surface of the ophthalmological lens so as to focus a part of the pencil on the overfocus side relative to the retina using a refractive action of the predetermined location (AP), and

(3) the predetermined location (AP), which is provided on at least one of the eyeball-side surface and the object-side surface of the ophthalmological lens, includes a different-refractive-index-material region having a refractive index different from the

refractive index of the base portion (BP), so as to focus a part of the pencil on the overfocus side relative to the retina using a reciprocal action of the predetermined location (AP) and the base portion (BP), wherein by passing the pencil through the passing region with a diameter of 4 mm, in which both of the predetermined location (AP) and the base portion (BP) are encompassed, a high-order monochromatic aberration having a fourth order or higher is added to the pencil.

[Claim 2] The ophthalmological lens according to claim 1, wherein the dominant wavelength is in a range of 532 to 575 nm.

[Claim 3] The ophthalmological lens according to claim 1 or 2, wherein the wavelength filter attenuates light with a wavelength in a range of 564 to 570 nm.

[Claim 4] The ophthalmological lens according to any one of claims 1 to 3, wherein the ophthalmological lens is an eyeglass lens.