[9] (where n_i is a refractive index of the reflective and refractive member, a is an angle between an incident surface of the reflective and refractive member and a first reflective surface adjacent to the incident surface, b is an incident angle of light incident on the reflective and refractive member, and C1 and C2 are a coefficient of a linear equeation and a constant respectively, when an inverse sine function for a reciprocal of the refractive index of the reflective and refractive member is expressed as a linear equation for the reciprocal of the refractive index of the reflective and refractive member),

[10] [Formula 2]

[11] $10° < a < 50°$

[12] [Formula 3]

[13] $b < 45°$

[14] [Formula 4]

[15] $1.1 < C1 < 1.4$

[16] [Formula 5]

[17] $-0.3 < C2 < +0.3$

[18] According to an embodiment of the disclosure, an electronic device may be provided. The electronic device may include a reflective and refractive member configured to reflect and/or refract at least a portion of light, and an image sensor configured to detect at least a portion of light passing through the reflective and refractive member. The reflective and refractive member may include a first surface on which light is incident and a second surface inclined with respect to the first surface. The reflective and refractive member may be configured to totally reflect at least a portion of light incident on the reflective and refractive member by satisfying the following Formula 9, Formula 10, Formula 11, Formula 12, and Formula 13 regarding a total reflection function inside the reflective and refractive member.

[19] [Formula 9]

[20] $$TRF=\frac{C1+b}{2a-C2}$$

[21] (where a is an angle between the first surface and the second surface adjacent to the first surface, b is an incident angle of light incident on the reflective and refractive member, and C1 and C2 are a coefficient of a linear equation and a constant, respectively, when an inverse sine function for a reciprocal of a refractive index of the reflective and refractive member is expressed as a linear equation for the reciprocal of the refractive index of the reflective and refractive member).

[22] [Formula 10]

[23] $10° < a < 50°$

[24] [Formula 11]

[25] $b < 45°$

[26] [Formula 12]

[27] $1.1 < C1 < 1.4$

[28] [Formula 13]

[29] $-0.3 < C2 < +0.3$

【Brief Description of Drawings】

[30] The above or other aspects, configurations, and/or advantages of an embodiment of the disclosure may become more apparent from the following detailed description with reference to the accompanying drawings.

[31] FIG. 1 is a diagram illustrating a camera module including a reflective and refractive member.

[32] FIG. 2 is a diagram illustrating a camera module including a reflective and refractive member.

[33] FIG. 3 is a diagram illustrating a camera module including a reflective and refractive member.

[34] FIG. 4 is an enlarged view illustrating a portion of a reflective and refractive member.

totally reflected and then emitted.

[48] FIG. 14B is a diagram illustrating a state in which light incident at a second angle on a reflective and refractive member having a second included angle and a third refractive index is totally reflected and then emitted.

[49] FIG. 14C is a diagram illustrating a state in which light incident at a second angle on a reflective and refractive member having a second included angle and a fourth refractive index is emitted back through a first surface.

[50] FIG. 15 is a perspective view illustrating a reflective and refractive member including an effective incident area.

[51] FIG. 16A is a diagram illustrating movement paths of light passing through an ineffective incident area and light passing through an effective incident area.

[52] FIG. 16B is a diagram illustrating a movement path of light passing through an effective incident area.

[53] FIG. 16C is a diagram illustrating a reflective and refractive member including a cut surface.

[54] FIG. 17 is a block diagram illustrating an electronic device (e.g., an optical device) in a network environment according to various embodiments.

[55] FIG. 18 is a block diagram illustrating a camera module according to various embodiments.

[56] Throughout the accompanying drawings, similar reference numerals may be assigned to similar parts, components, and/or structures.

【Mode for Carrying out the Invention】

[57] A camera module including a reflective and refractive member such as a prism or a mirror may change the traveling direction of light inside the reflective and refractive member. The overall length of an optical system may be reduced and the height of the camera module

may be lowered by reflecting and/or refracting light more times using the reflective and refractive member.

[58] The disclosure may provide a camera module including a reflective and refractive member that satisfies a total reflection condition in order to reflect and/or refract the traveling direction of light more times inside the reflective and refractive member.

[59] The technical objects to be achieved by the disclosure are not limited to the technical objects mentioned above, and other technical objects not mentioned will be clearly understood by those skilled in the art from the following description.

[60] The following description of the accompanying drawings may provide an understanding of various exemplary implementations of the disclosure, including the claims and equivalents thereof. Although an exemplary embodiment disclosed in the following description includes various specific details to aid understanding, these are considered to be merely one of various exemplary embodiments. Accordingly, those skilled in the art will understand that various changes and modifications may be made to various implementations described herein without departing from the scope and spirit of the disclosure. Additionally, a description of well-known functions and configurations will be avoided for clarity and conciseness.

[61] The terms and words used in the following description and claims are not limited to their bibliographical meanings but may be used to clearly and consistently describe an embodiment of the disclosure. Therefore, it will be apparent to those skilled in the art that the following description of various implementations of the disclosure is provided for illustration purposes only and not for the purpose of limiting the disclosure as defined by the scope of the claims and their equivalents.

[62] It should be understood that the singular forms "a," "an," and "the" include plural referents unless the context clearly dictates otherwise. Thus, for example, a reference to "a component surface" may be understood as including one or more surfaces of the component.

reflective area so that the incident light may be reflected inside the reflective and refractive member 400. According to an embodiment, the reflective area may be formed to surround the incident area.

[81] In another example, the partial area of the exit surface may correspond to an exit area (e.g., an exit portion 401b in FIG. 3) through which light is emitted, and the remaining area excluding the partial area may correspond to a reflective area so that light may be reflected inside the reflective and refractive member 400. According to an embodiment, the reflective area may be formed to surround the exit area.

[82] According to an embodiment, light reflection may occur even in the incident area of the incident surface 401. For example, when light that has entered the reflective and refractive member 400 through a portion of the incident area of the incident surface 401 passes through a reflective surface (e.g., the first reflective surface 402) and reaches another portion of the incident area again, the light at the other portion of the incident area may be reflected and continue to travel inside the reflective and refractive member 400 rather than exiting to the outside through the incident area.

[83] According to an embodiment, a portion or the entirety of the inner surface of the incident area may be treated with a coating so that light that has passed through the incident area may be reflected when it reaches the incident area again. According to an embodiment, the outer surface of the incident surface and/or the exit surface of the reflective and refractive member may be coated with a material that reduces reflectivity, and the inner surface of the incident surface and/or the exit surface may be coated with a material having higher reflectivity (e.g., a mirror coating) than the outer surface.

[84] According to an embodiment, the incident surface 401 of the reflective and refractive member 400 may be referred to as a 'first surface,' the first reflective surface 402 as a 'second surface,' the second reflective surface 403 as a 'third surface,' and the exit surface 404 as a 'fourth

traveling along the optical axis O-I.

[87] FIG. 3 illustrates the reflective and refractive member 400 in a different shape from that in FIG. 2. Hereinafter, in describing various embodiments, for convenience, the description will focus on the reflective and refractive member 400 in the form (e.g., a parallelogram shape) corresponding to FIG. 2. However, this description may also be applied adaptively to the reflective and refractive member 400 in the form (e.g., a trapezoidal shape) corresponding to FIG. 3.

[88] According to the embodiments illustrated in FIGS. 2 and 3, although the reflective and refractive member 400 is shown as a single-piece component, it should be noted that the reflective and refractive member 400 may be formed by a combination of a plurality of reflective and refractive element pieces.

[89] According to an embodiment, the camera module 100 according to an embodiment of the disclosure may configured to enable total reflection (TR), which may be advantageous for the miniaturization of the camera module 100 and the electronic device including the same. With reference to FIGS. 4 to 16C, a detailed description will be given below of the reflective and refractive member 400 for TR (a reflective and refractive member 500 of FIGS. 4, 9A, 9B, and 10, a reflective and refractive member 500' of FIG. 11, a reflective and refractive member 600 of FIG. 12, a reflective and refractive member 600' of FIG. 13, a reflective and refractive member 700 of FIGS. 14A and 14B, a reflective and refractive member 700' of FIG. 14C, and a reflective and refractive member 800 of FIGS. 15 to 16C).

[90] FIG. 4 is a diagram illustrating a state in which light is refracted and/or reflected in a reflective and refractive member according to an embodiment. FIG. 4 is an enlarged view illustrating one end of the reflective and refractive member.

[91] As the reflective and refractive member 500 of FIG. 4, a reflective and refractive member 500 in the same shape as the reflective and refractive member 400 disclosed in FIGS. 2 and 3

[96] When light is incident from a medium with a high refractive index toward a medium with a low refractive index, a TR phenomenon may occur in which all light is reflected without being refracted. Referring to FIGS. 6A to 6C, in the case where the TR phenomenon is applied to an embodiment including a specific medium (e.g., a camera module), when light is incident from a medium with a high refractive index (e.g., the reflective and refractive member 500) toward a medium with a low refractive index (e.g., air outside the reflective and refractive member 500 within the camera module 100), if an incident angle θ_i is greater than a critical angle θ_c, the light is totally reflected from the interface (e.g., FIG. 6C) and does not transmitted into the medium with the low refractive index (e.g., the air outside the reflective and refractive member 500 within the camera module 100).

[97] Referring back to FIG. 4 with reference to FIGS. 5 to 6C, light P incident at the angle b at point B is refracted to have the angle b' by Snell's Law, the angle between the normal line N2 and the refracted light has a correlation with the angle a, which is the angle between the first surface 501 and the second surface 502 of the reflective and refractive member, and the light is reflected at point C at the angle a-b' with the normal N2. Then, the reflected light is incident at point D at an angle of 2(a-b')+b' with respect to the normal N3. For TR, the ray incident at point D should have an angle greater than or equal to a critical angle derived by the following equation(s).

[98] First, Formula 1 for applying Snell's Law is given as follows.

[99] [Formula 1]

[100] $n_i \times \sin\theta_i = n_t \times \sin\theta_t$

[101] Herein, n_i may be the refractive index of the reflective and refractive member 500, and n_t may be the refractive index of air outside the reflective and refractive member 500 within the camera module 100. Assuming the above equation is under paraxial conditions, $\sin\theta_i$ may be substituted with $\tan\theta_i$ or v_i, and $\sin\theta_t$ may be substituted with $\tan\theta_t$ or v_t. However, the angle θ

may be expressed in units of radians (rad). Accordingly, [Formula 1] may be summarized as [Formula 2] below.

[102] [Formula 2]

[103] $n_i \times v_i = n_t \times v_t$

[104] As illustrated in FIG. 6B, in relation to the critical angle θ_c, [Formula 2] may be summarized as [Formula 3] below.

[105] [Formula 3]

[106] $\sin \theta_c = n_t/n_i$

[107] For the critical angle θ_c, this may be summarized again as the following [Formula 4].

[108] [Formula 4]

[109] $\theta_c = \sin^{-1}(n_t/n_i)$

[110] Since the refractive index n_t of the air outside the reflective and refractive member 500 within the camera module 100 is substantially the refractive index ($n_{air}=1$) of air, [Formula 4] may be summarized as [Formula 5] below.

[111] [Formula 5]

[112] $\theta_c = \sin^{-1}(1/n_i)$

[113] To satisfy the TR condition, the angle 2(a-b')+b' of the reflected light incident at point D should be greater than θ_c. That is, the following [Formula 6] should be satisfied.

[114] [Formula 6]

[115] $2(a-b')+b' > \theta_c$

[116] [Formula 6] may be expressed as [Formula 7] below.

[117] [Formula 7]

[118] $2(a-b')+b' > \sin^{-1}(1/n_i)$

[119] $\sin^{-1}(1/n_i)$ may be expressed as a Taylor expansion by [Formula 8] below.

[120] [Formula 8]

[121] $\sin^{-1}(1/n_i) = (1/n_i) + (1/2) \times ((1/n_i)^3/3) + (1/2)\times(3/4)\times(1/n_i)^5/5) + \ldots$

[122] As an optical material applied to the camera module 100, the refractive index of the reflective and refractive member 500 may range from approximately 1.5 to 2.2 depending on the material. For example, when the reflective and refractive member 500 includes a synthetic resin material, it may have a refractive index of 1.5 to 1.78. In another example, when the reflective and refractive member 500 includes a glass material, it may have a refractive index of 1.79 to 2.2. A correlation function as illustrated in FIG. 7 may be obtained by summarizing values derived by substituting such refractive indexes into Formula 8.

[123] FIG. 7 is a graph illustrating the correlation between $1/n$ (e.g., $1/n_i$) and an inverse sine function (e.g., $\sin^{-1}(1/n_i)$).

[124] The following [Table 1] illustrates $1/n_i$ values and the inverse sine function (e.g., $\sin^{-1}(1/n_i)$) derived using Taylor series, for refractive indexes n_i in the range of approximately 1.5 to 2.2. When the horizontal axis (x axis) is $1/n_i$ and the vertical axis (y axis) is $\sin^{-1}(1/n_i)$, the data in [Table 1] may be represented as illustrated in FIG. 7.

[125] [Table 1]

n_i	$1/n_i$	$\sin^{-1}(1/n_i)$
1.5	0.67	0.73
1.6	0.63	0.68
1.7	0.59	0.63
1.8	0.56	0.59
1.9	0.53	0.55
2	0.50	0.52
2.1	0.48	0.50
2.2	0.45	0.47

[126] Connecting the traces of the data in [Table 1] plotted on the x-y coordinate axes of FIG. 7 results in a graph resembling a linear function, which may be approximated as y = 1.2397x - 0.0963. A correlation coefficient function between a horizontal axis displacement $1/n_i$ and a vertical axis displacement $\sin^{-1}(1/n_i)$ in FIG. 7 may be expressed as a determination coefficient R^2. For example, as illustrated in FIG. 7, when the refractive index of the reflective and refractive member 500 is in the range of approximately 1.5 to 2.2, the correlation coefficient R^2 is 0.9988, confirming a very high positive correlation. Accordingly, $\sin^{-1}(1/n_i)$ in [Formula 8] may be expressed as an approximation equation like [Formula 9] below.

[127] [Formula 9]

[128] $\sin^{-1}(1/n_i) \fallingdotseq C1 \times (1/n_i) + C2$

[129] C1 and C2 may refer to the coefficient of the linear equation and the constant, respectively, when the inverse sine function for the reciprocal of the refractive index of the reflective and refractive member 500 is expressed as a linear equation for the reciprocal of the refractive index of the reflective and refractive member 500. For example, FIG. 7 illustrates C1 as 1.2397 and C2 as -0.0963.

[130] Substituting [Formula 9] into [Formula 7] results in [Formula 10] below.

[131] [Formula 10]

[132] $2(a-b')+b' > C1\times (1/n_i) + C2$

[133] Rearranging [Formula 10] into an equation for the refractive index of the reflective and refractive member 500 results in [Formula 11] below.

[134] [Formula 11]

[135] $$n_i \geq \frac{C1+b}{2a-C2}$$

[136] An equation for a refractive index required for TR occurrence in the reflective and refractive member 500 may be defined as [Formula 11]. In [Formula 11], the expression ‘ $\frac{C1+b}{2a-C2}$ ’ may also be referred to as a total reflection function (TRF). [Formula 11] may be referred to as [Formula 1] in the following claims, and in [Formula 11], ‘ $\frac{C1+b}{2a-C2}$ ’ may also be referred to as [Formula 9] in the following claims. Referring to the correlation equation in [Table 1] and/or FIG. 7, the range of C1 and C2 may be derived as illustrated in [Formula 12] and [Formula 13] below.

[137] [Formula 12]

[138] $1.1 < C1 < 1.4$

[139] [Formula 13]

[140] $-0.3 < C2 < +0.3$

[141] For example, an embodiment in which C1 = 1.2397 and C2 = -0.0963 is illustrated in FIG. 7. The upper and lower limits of C1 in Formula 12 and the upper and lower limits of C2 in

Formula 13 may correspond to upper and lower limits corresponding to a range where the determination coefficient R^2 of the correlation coefficient function is 0.90 or higher.

[142] According to an embodiment, the cause of the reflection of light refracted at point B at point C at an angle of a-b' may be, but is not necessarily limited to, a reflective material such as a mirror formed on the second surface 502. According to another example, the reflective and refractive member 500 may achieve TR at point C as well as at point D. According to another embodiment, the reflective and refractive member 500 may achieve TR at other points not shown in addition to point C and point D. In this case, the camera module 100 of the disclosure may be referred to as a camera module implementing multi total reflection (MTR).

[143] FIG. 8 is a schematic diagram illustrating the relationship between an F-number and a numerical aperture (N.A).

[144] In the reflective and refractive member 500 of the disclosure, TR may occur only when the incident angle b (e.g., the incident angle b in FIG. 4) of an incident ray is within a range less than or equal to a specified angle. Referring to FIG. 8, the incident angle b may be expressed as an equation related to a major factor F-number (Fno) of an optical system.

[145] Referring to FIG. 8, the F-number is a parameter for gauging the brightness of an optical system and may be expressed as [Formula 14] below.

[146] [Formula 14]

[147] $Fno=f/D$

[148] Fno represents the F-number, f represents the effective focal length (EFL) of the optical system, and D represents an entrance pupil diameter (EPD).

[149] Fno may be depicted as the central light flux of a lens, and thus may be expressed by the following [Formula 15] related to an aperture through a simple approximation.

[150] [Formula 15]

[151] $Fno = 1/(2\times N.A)$

[152] N.A (numerical aperture) represents the numerical aperture. When N.A is expressed using a maximum incident angle θ of a ray entering the lens aperture among rays passing through the focus of a lens disposed in a medium with a refractive index n_t, it may be expressed as [Formula 16] below.

[153] [Formula 16]

[154] $N.A = n_t \times \sin\theta$

[155] When the value of θ is small, sinθ may be approximated as θ, and thus [Formula 16] may be summarized as [Formula 17] below.

[156] [Formula 17]

[157] $N.A = n_t \times \theta$

[158] Based on [Formula 16] and [Formula 17], [Formula 15] may be summarized as [Formula 18] below.

[159] [Formula 18]

[160] $Fno = 1/(2 \times n_t \times \theta)$

[161] Since a medium having the refractive index n_t around the lens is air, n_t may be substituted with the refractive index ($n_{air}=1$) of air. Further, [Formula 18] may be summarized as [Formula 19] or [Formula 20] below by defining the maximum incident angle θ as corresponding to the incident angle b on the reflective and refractive member 500.

[162] [Formula 19]

[163] $Fno = 1/(2 \times b)$

[164] [Formula 20]

[165] $b = 1/(2 \times Fno)$

[166] A minimum refractive index of the reflective and refractive member 500 required for TR occurrence according to Fno may be derived through [Formula 11] by substituting [Formula 19] or [Formula 20] into [Formula 11].

[167] FIG. 9A is a schematic diagram illustrating a light path LP of light that is incident on and then emitted from a reflective and refractive member. FIG. 9B is an enlarged view illustrating a portion A of the reflective and refractive member. FIG. 10 is a diagram illustrating a state in which light incident on a reflective and refractive member is emitted back from a first surface. FIG. 11 is a diagram illustrating a state in which light incident on a reflective and refractive member is totally reflected from a first surface.

[168] Referring to FIG. 9A, the reflective and refractive member 500 (e.g., the reflective and refractive member 300 of FIG. 1 or the reflective and refractive member 400 of FIGS. 2 and 3) includes the first surface 501 (e.g., the first surface 301 of FIG. 1 or the first surface 401 of FIGS. 2 and 3), the second surface 502 (e.g., the second surface 302 of FIG. 1 or the second surface 402 of FIGS. 2 and 3), a third surface 503 (e.g., the second reflective surface 305 of FIG. 1 or the third surface 403 of FIGS. 2 and 3), and a fourth surface 504 (e.g., the third reflective surface 306 of FIG. 1 or the fourth surface 404 of FIGS. 2 and 3).

[169] Referring to FIGS. 9A and 9B, it is illustrated that incident light P is incident perpendicularly to the first surface 501 of the reflective and refractive member 500, and emitted light Q is output. In this case, the requirement for TR when the incident light P is incident may be determined by the angle (hereinafter, referred to as 'included angle a') between the first surface 501 and the second surface 502. In contrast, when the incident light P is incident obliquely with respect to the first surface 501 as illustrated in FIGS. 10 and 11, the TR requirement may be determined according to the included angle a of the reflective and refractive member 500 together with an incident angle b with respect to a normal line N of the first surface 501.

[170] With reference to FIGS. 10 and 11, the TR requirement according to the incident angle b of light incident on the reflective and refractive member 500 and the included angle a of the reflective and refractive member 500 will be described below in detail.

[171] Fno may be pre-specified according to optical performance (or specifications) required for the camera module 100. According to an embodiment, the camera module 100 may be provided, in which as Fno decreases, brightness increases and as Fno increases, the brightness decreases.

[172] For example, when Fno is 2.8, the corresponding incident angle b calculated in degrees rather than radians (rad), is 10.23°. In this case, a minimum refractive index according to various embodiments of the included angle a of the reflective and refractive member 500 may be as illustrated in [Table 2] below.

[173] Various embodiments for a range of the included angle a of the reflective and refractive member 500 of the disclosure may be given as [Formula 21] below. Various embodiments for a range of the incident angle b of light incident on the reflective and refractive member 500 may be given as [Formula 22] below.

[174] [Formula 21]

[175] $10° < a < 50°$

[176] [Formula 22]

[177] $b < 45°$

[178] For example, when the included angle a in [Formula 21] is greater than or equal to 50, the height of the reflective and refractive member 500 is large, which may make the overall thickness of the camera module excessively large. For example, when the included angle a in [Formula 21] is less than or equal to 10, it may be difficult to manufacture the reflective and refractive member 500, and the risk of damage may be high. Regarding Formula 22, when the reflective and refractive member 500 is included in the camera module, the incident angle b of light passing through, for example, the lens assembly and incident on the reflective and refractive member 500 may be set to less than 45 degrees.

[179] [Table 2]

Included angle	Incident angle according to Fno	Minimum refractive index	Included angle	Incident angle according to Fno	Minimum refractive index
a	b	n	a	b	n
45°	10.23°	0.85	22°	10.23°	1.64
40°	10.23°	0.95	20°	10.23°	1.79
35°	10.23°	1.08	18°	10.23°	1.96
30°	10.23°	1.24	16°	10.23°	2.17
28°	10.23°	1.32	14°	10.23°	2.43
26°	10.23°	1.41	12°	10.23°	2.75
24°	10.23°	1.52	10°	10.23°	3.19

[180] According to [Table 2], it may be identified that as the included angle of the reflective and refractive member decreases, the minimum refractive index for TR occurrence gradually increases. For example, as illustrated in [Table 2], when the incident angle b according to Fno is 10.23° and the included angle a of the reflective and refractive member 500 is 45 degrees, the minimum refractive index required for the medium of the reflective and refractive member 500 to achieve TR inside the reflective and refractive member 500 is 0.85. That is, under the 45-degree condition, the reflective and refractive member 500 should have a refractive index of at

emitted. FIG. 13 is a diagram illustrating a state in which light incident on a reflective and refractive member having the first included angle and a second refractive index is emitted back from a first surface.

[190] Referring to FIGS. 12 and 13, reflective and refractive members 600 and 600' (e.g., the reflective and refractive member 300 of FIG. 1, the reflective and refractive member 400 of FIGS. 2 and 3, or the reflective and refractive members 500 and 500' of FIGS. 4 and FIGS. 9A to 11) may include first surfaces 601 and 601' (e.g., the first surface 301 of the reflective and refractive member 300 of FIG. 1, the first surface 401 of the reflective and refractive member 400 of FIGS. 2 and 3, or the first surface 501 of the reflective and refractive members 500 and 500' of FIGS. 4 and FIGS. 9A to 11), second surfaces 602 and 602' (e.g., the second surface 302 of the reflective and refractive member 300 of FIG. 1, the second surface 402 of the reflective and refractive member 400 of FIGS. 2 and 3, or the second surface 502 of the reflective and refractive members 500 and 500' of FIGS. 4 and FIGS. 9A to 11), third surfaces 603 and 603' (e.g., the second reflective surface 305 of the reflective and refractive member 300 of FIG. 1, the third surface 403 of the reflective and refractive member 400 of FIGS. 2 and 3, or the third surface 503 of the reflective and refractive members 500 and 500' of FIGS. 4 and FIGS. 9A to 11), and fourth surfaces 604 and 604' (e.g., the third reflective surface 306 of the reflective and refractive member 300 of FIG. 1, the fourth surface 404 of the reflective and refractive member 400 of FIGS. 2 and 3, or the fourth surface 504 of the reflective and refractive members 500 and 500' of FIGS. 4 and FIGS. 9A to 11).

[191] For example, in the embodiments of FIGS. 12 and 13, the first included angle may be 30°. However, this may be variously changed according to embodiments. In the embodiments of FIGS. 12 and 13, when the Abbe number is 40 and the required Fno is 2.8, the TRF may be 1.24. In this case, FIG. 12 may illustrate a light path LP when the refractive index n_i of the reflective and refractive member 600 is 1.7, and FIG. 13 may illustrate a light path LP when the refractive

index n_i of the reflective and refractive member 600 is 1.15. Referring to FIGS. 12 and 13, it may be identified that TR occurs when the reflective and refractive member 600 has a refractive index greater than the TRF (e.g., FIG. 12), and TR does not occur when it has a refractive index smaller than the TRF (e.g., FIG. 13).

[192] FIG. 14A is a diagram illustrating a state in which light incident at a first angle on a reflective and refractive member having a second included angle and a third refractive index is totally reflected and emitted. FIG. 14B is a diagram illustrating a state in which light incident at a second angle on a reflective and refractive member having the second included angle and the third refractive index is totally reflected and emitted. FIG. 14C is a diagram illustrating a state in which light incident at the second angle on a reflective and refractive member having the second included angle and a fourth refractive index is emitted back through the first surface.

[193] Referring to FIGS. 14A to 14C, reflective and refractive members 700 and 700' (e.g., the reflective and refractive member 300 of FIG. 1, the reflective and refractive member 400 of FIGS. 2 and 3, the reflective and refractive members 500 and 500' of FIGS. 4 and FIGS. 9A to 11, or the reflective and refractive members 600 and 600' of FIGS. 12 and 13) may include first surfaces 701 and 701' (e.g., the first surface 301 of FIG. 1, the first surface 401 of FIGS. 2 and 3, the first surfaces 501 and 501' of FIGS. 4 and FIGS. 9A to 11, or the first surfaces 601 and 601' of FIGS. 12 and 13), second surfaces 702 and 702' (e.g., the second surface 302 of FIG. 1, the second surface 402 of FIGS. 2 and 3, the second surface 502 of FIGS. 4 and FIGS. 9A to 11, or the second surfaces 602 and 602 of FIGS. 12 and 13), third surfaces 703 and 703' (e.g., the second reflective surface 305 of FIG. 1, the third surface 403 of FIGS. 2 and 3, the third surface 503 of FIGS. 4 and FIGS. 9A to 11, or the third surfaces 603 and 603' of FIGS. 12 and 13), and fourth surfaces 704 and 704' (e.g., the third reflective surface 306 of FIG. 1, the fourth surface 404 of FIGS. 2 and 3, the fourth surface 504 of FIGS. 4 and FIGS. 9A to 11, or the fourth surfaces 604 and 604' of FIGS. 12 and 13).

[194] For example, the included angle a of the reflective and refractive members 700 and 700' may be expressed as a second included angle a' in the embodiments of FIGS. 14A to 14C. For example, in the embodiments of FIGS. 14A to 14C, the second included angle a' may be 25°. However, this may be changed in various ways according to embodiments. In the embodiments of FIGS. 14A to 14C, when the Abbe number is 30 and the required Fno is 2.8, the TRF may be 1.46. In this case, FIGS. 14A and 14B may illustrate a light path LP in the reflective and refractive member 700 having a refractive index n_i of 1.75, and FIG. 14C may illustrate a light path LP in the reflective and refractive member 700' having a refractive index n_i of 1.35. Referring to FIGS. 14A and 14B, it may be identified that when the refractive index n_i of the reflective and refractive member 700 is 1.75, TR occurs within the reflective and refractive member 700 not only when incident light P is incident perpendicularly to the first surface 701 but also when it is incident obliquely. On the contrary, referring to FIGS. 14B and 14C, for obliquely incident light P, it may be identified that TR occurs when the reflective and refractive members 700 and 700' have refractive indexes greater than the TRF (e.g., the reflective and refractive member 700 of FIG. 14B), and TRF does not occur when they have refractive indexes smaller than the TRF (e.g., the reflective and refractive member 700' of FIG. 14C).

[195] FIG. 15 is a perspective view illustrating a reflective and refractive member including an effective incident area. FIG. 16A is a diagram illustrating travel paths of light passing through an ineffective incident area and light passing through an effective incident area. FIG. 16B is a diagram illustrating a travel path of light passing through an effective incident area. FIG. 16C is a diagram illustrating a reflective and refractive member including a cut surface.

[196] Referring to FIGS. 15 to 16C, a reflective and refractive member 800 (e.g., the reflective and refractive member 300 of FIG. 1, the reflective and refractive member 400 of FIGS. 2 and 3, the reflective and refractive members 500 and 500' of FIGS. 4 and FIGS. 9A to 11, the reflective and refractive members 600 and 600' of FIGS. 12 and 13, or the reflective and refractive

members 700 and 700' of FIGS. 14A to 14C) may include a first surface 801 (e.g., the first surface 301 of FIG. 1, the first surface 401 of FIGS. 2 and 3, the first surfaces 501 and 501' of FIGS. 4 and FIGS. 9A to 11, the first surfaces 601 and 601' of FIGS. 12 and 13, or the first surfaces 701 and 701' of FIGS. 14A to 14C), a second surface 802 (e.g., the second surface 302 of FIG. 1, the second surface 402 of FIGS. 2 and 3, the second surface 502 of FIGS. 4 and FIGS. 9A to 11, the second surfaces 602 and 602' of FIGS. 12 and 13, or the second surfaces 702 and 702' of FIGS. 14A to 14C), a third surface 803 (e.g., the second reflective surface 305 of FIG. 1, the third surface 403 of FIGS. 2 and 3, the third surface 503 of FIGS. 4 and FIGS. 9A to 11, the third surfaces 603 and 603' of FIGS. 12 and 13, or the third surfaces 703 and 703' of FIGS. 14A to 14C), and a fourth surface 804 (e.g., the third reflective surface 306 of FIG. 1, the fourth surface 404 of FIGS. 2 and 3, the fourth surface 504 of FIGS. 4 and FIGS. 9A to 11, the fourth surfaces 604 and 604' of FIGS. 12 and 13, or the fourth surfaces 704 and 704' of FIGS. 14A to 14C).

[197] Referring to FIG. 15, according to an embodiment, the first surface 801 may include a first area 8011 and a second area 8012. The first area 8011 may be an incident area where light is incident. As described above in the description of the embodiments of FIGS. 2 and 3, when light passing through the first area 8011 is reflected from the second surface 802 and reaches the first area 8011 again, the light may be reflected even in the first area 8011.

[198] The first area 8011 may be disposed at a position corresponding to a lens assembly (e.g., the lens assembly 200 of FIGS. 1 to 3) and have a circular shape with a specific diameter. According to an embodiment, the second area 8012 may be the remaining area of the first surface 801 other than the first area 8011. The second area 8012 may have a shape surrounding the first area 8011. According to an embodiment, the first area 8011 may be disposed at a position spaced from an end (e.g., a vertex of an edge) of the first surface 801 by a predetermined distance. According to an embodiment, the first area 8011 may be referred to as an effective incident area (EIA). With reference to FIGS. 16A and 16B, the EIA will be

described below in detail.

[199] Referring to FIG. 16A, light is shown as being incident at two points through the first surface 801. In a first light path LP1 which is a path of light incident on the second area 8012 other than the first area 8011 which is the EIA, light may be incident along a path of point A1 and point B1 and emitted through point C1, point D1, and point E1. In a second light path LP2 which is a path of light incident on the first area 8011 which is the EIA, light may be incident along a path of point A2 and point B2 and emitted through point C2, point D2, and point E2.

[200] The first light path LP1 may have a path in which light is incident through the first surface 801, then reflected (primarily reflected) from the second surface 802, re-reflected (secondarily reflected) from the first surface 801, and then reflected again (tertiarily reflected) from the second surface 802. For example, as in the first light path LP1 illustrated in FIG. 16A, when light is emitted through the fourth surface 804, it may be emitted in an oblique direction rather than a direction perpendicular to the fourth surface 804 in a light path (hereinafter, referred to as a 'path of tertiary reflection on the second surface 802') having a path in which light is secondarily reflected from the first surface 801 and then tertiarily reflected from the second surface 802. Regarding the angles of the light path when light is reflected again from the second surface 802 after being re-reflected from the first surface 801 in the first light path LP1, an angle θ_{D1} at point D1 is formed to be different from an angle θ_{E1} at point E1. The path of tertiary reflection on the second surface 802 may be formed irregularly.

[201] The second light path LP2 may have a path (hereinafter, referred to as a 'path of tertiary reflection on the fourth surface 804') in which light is incident through the first surface 801, then reflected (primarily reflected) from the second surface 802, re-reflected (secondarily reflected) from the first surface 801, and then reflected again (tertiarily reflected) from the fourth surface 804. For example, as in the second light path LP2 illustrated in FIG. 16A, when light is emitted through the fourth surface 804, it may be emitted in a direction perpendicular to the fourth

surface 804 in the light path (hereinafter, referred to as the 'path of tertiary reflection on the fourth surface 804') having a path in which light is secondarily reflected from the first surface 801 and then tertiarily reflected from the fourth surface 804. Regarding the angles of the light path when light is reflected from the fourth surface 804 after being re-reflected from the first surface 801 in the second light path LP2, an angle θ_{D2} at point D2 may be formed to be identical to an angle θ_{E2} at point E2. That is, in the second light path LP2, an angle at which light is re-reflected from the first surface 801 and an angle at which the light is subsequently reflected again may be identical. In the embodiment of FIG. 16A, the second light path LP2 may be regular compared to the first light path LP1. According to an embodiment, in designing the reflective and refractive member 800, the second light path LP2 having such a regular path may be set as a normal light path. The camera module may be designed optimally for the arrangement and/or shape of the reflective and refractive member to enhance optical performance based on the normal light path.

[202] According to an embodiment, in the reflective and refractive member 800 of the disclosure, the first area 8011 where light is incident may be set as an EIA which has a light path in which light is secondly reflected from the first surface 801 and then tertiarily reflected from the fourth surface 804. Accordingly, all light incident on the first area 8011 may be included in the normal light path which is a regular light path. According to an embodiment, the first area 8011 may have a first end p1 at a position spaced from a vertex between the first surface 801 and the second surface 802 by a first distance l1, and a second end p2 at a position spaced from the vertex between the first surface 801 and the second surface 802 by a second distance l2. In order for all light paths of light incident on the first area 8011 to be included in the regular normal light path, the position of the first end p1 may be set to a position which enables formation of a path in which light incident on the first area 8011 is tertiarily reflected from the fourth surface 804. Alternatively, the position of the first end p1 may be set to a position which enables formation of

a path in which the angles of the secondary reflection and the tertiary reflection of light incident on the first area 8011 are identical. According to an embodiment, the position of the second end p2 may be set to a position where an imaginary line (e.g., a dash-dotted line in FIG. 16A) drawn perpendicular to the first surface 801 from a vertex between the second surface 802 and the fourth surface 804 intersects with the first surface 801.

[203] According to an embodiment, the second area 8012 may include an area of the first surface 801 other than the first area 8011. Referring to FIG. 16A, the second area 8012 may include a $(2\text{-}1)^{th}$ area 8012a close to the vertex between the first surface 801 and the second surface 802 with respect to the first area 8011. The second area 8012 may also include a $(2\text{-}2)^{th}$ area 8012b located on the opposite side of the $(2\text{-}1)^{th}$ area 8012a with respect to the first area 8011. According to an embodiment, even if light is incident on the $(2\text{-}1)^{th}$ area 8012a, a light path may be formed irregularly. According to an embodiment, a portion of the reflective and refractive member 800 corresponding to the $(2\text{-}1)^{th}$ area 8012a may be processed (e.g., cut). An example of the reflective and refractive member 800 with a processed portion is illustrated in FIG. 16C.

[204] Referring to FIG. 16B, similar to the embodiment of FIG. 16A, light is also shown as being incident at two points through the first surface 801 in the embodiment of FIG. 16B. In a first light path LP1 which is a path of light incident on the first area 8011 being the EIA, light may be incident along a path of point A1 and point B1 and emitted through point C1, point D1, and point E1. In a second light path LP2 which is a path of light incident on the first area 8011 being the EIA, light may be incident along a path of point A2 and point B2 and emitted through point C2, point D2, and point E2. In the embodiment of FIG. 16B, light is shown as being incident through the first area 8011 which is the EIA in both the first light path LP1 and the second light path LP2. In this case, it may be identified that an angle θ_{D1} at point D1 is set identical to an angle θ_{E1} at point E1 in the first light path LP1, and an angle θ_{D2} at point D2 is set

identical to an angle θ_{E2} at point E2 in the second light path LP2.

[205] In summary of the embodiments of FIGS. 16A and 16B, the reflective and refractive member 800 according to an embodiment of the disclosure may include regular and irregular paths of light incident into the reflective and refractive member 800. An incident area of light leading to the regular path in the reflective and refractive member 800 may be specified as an EIA. According to an embodiment, the EIA may be set as the first area 8011. The first area 8011 may be surrounded by the second area 8012. It may be determined whether the light incident on the reflective and refractive member 800 has a regular light path, based on light incident perpendicularly to the first surface 801. According to an embodiment, the reflective and refractive member 800 may satisfy the following [Formula 24].

[206] [Formula 24]

[207] $p1 \leq EIA$

[208] EIA may represent the EIA in which light incident on the reflective and refractive member 800 forms a regular light path. p1 may be a first end of the first area 8011 corresponding to the EIA. According to an embodiment, p1 may correspond to a point closest to the vertex between the first surface 801 and the second surface 802, where light incident on the reflective and refractive member 800 has a regular light path. For example, when the EIA of light incident on the reflective and refractive member member 800 is set smaller than p1, the light incident on the reflective and refractive member 800 may have an irregular light path and/or oblique light may be emitted from the exit surface of the reflective and refractive member 800.

[209] According to an embodiment, the reflective and refractive member 800 may satisfy the following [Formula 25].

[210] [Formula 25]

[211] $p1 \leq EIA \leq p2$

[212] p2 may be a second end of the first area 8011 corresponding to the EIA. According to an embodiment, p2 may be set to a position where an imaginary line (e.g., the dash-dotted line in FIG. 16A) drawn perpendicular to the first surface 801 from the vertex between the second surface 802 and the fourth surface 804 intersecting with the first surface 801.

[213] Various embodiments for the included angle a of the reflective and refractive member 800 of the disclosure may be given as [Formula 26] below.

[214] [Formula 26]

[215] $10° < a < 30°$

[216] For example, when the included angle a in [Formula 26] is greater than or equal to 30, the angles of the secondary reflection and the tertiary reflection of light incident on the first area 8011 of the reflective and refractive member 800 may not be formed to be identical. For example, when the included angle a in [Formula 26] is less than or equal to 10, it may be difficult to manufacture the reflective and refractive member 800, and the risk of damage may be high.

[217] Referring to FIG. 16C, a portion of the reflective and refractive member 800 may be processed (e.g., cut). The size of the reflective and refractive member 800 may be reduced or the possibility of damage during handling may be decreased by processing (e.g., cutting) the portion of the reflective and refractive member 800. The reflective and refractive member 500 may include a plurality of cut surfaces depending on an embodiment. According to an embodiment, the reflective and refractive member 800 may include a cut surface (e.g., a first cut surface 805) formed by removing a vertex portion between the first surface 801 and the second surface 802. To the same effect, it may also include a cut surface (e.g., a second cut surface 806) formed by removing a vertex portion between the third surface 803 and the fourth surface 804.

[218] According to an embodiment, light incident into the reflective and refractive member may be prevented from leaking to the outside by masking or mirror-coating at least a portion of the first surface 801, at least a portion of the second surface 802, at least a portion of the third surface 803, at least a portion of the fourth surface 804, and/or the cut surface (e.g., the first cut

various embodiments, the integrated component may still perform one or more functions of each of the plurality of components in the same or similar manner as they are performed by a corresponding one of the plurality of components before the integration. According to various embodiments, operations performed by the module, the program, or another component may be carried out sequentially, in parallel, repeatedly, or heuristically, or one or more of the operations may be executed in a different order or omitted, or one or more other operations may be added.

[255] According to an embodiment of the disclosure, the camera module 100 may be provided. The camera module may include the lens assembly 200, at least one reflective and refractive member 300, 400, 500, 500', 600, 600', 700, 700', or 800 in which light is reflected and/or refracted at least twice, and the image sensor IS. The reflective and refractive member 300, 400, 500, 500', 600, 600', 700, 700', or 800 may be configured to totally reflect at least a portion of light incident on the reflective and refractive member by satisfying the following Formula 1, Formula 2, Formula 3, Formula 4, and Formula 5 regarding a refractive index for total reflection inside the reflective and refractive member 300, 400, 500, 500', 600, 600', 700, 700', or 800.

[256] [Formula 1]

[257] $$n_i \geq \frac{C1+b}{2a-C2}$$

[258] (where n_i is a refractive index of the reflective and refractive member, a is an angle between the incident surface 301, 401, 501, 501', 601, 601', 701, 701', or 801 of the reflective and refractive member and the first reflective surface 302, 402, 502, 502', 602, 602', 702, 702', or 802 adjacent to the incident surface, b is an incident angle of light incident on the reflective and refractive member, and C1 and C2 are a coefficient of a linear equation and a constant, respectively, when an inverse sine function for a reciprocal of the refractive index of the reflective and refractive member is expressed as a linear equation for the reciprocal of refractive index of the reflective and refractive member.)

[259] [Formula 2]

[260] $10° < a < 50°$

[261] [Formula 3]

[262] $b < 45°$

[263] [Formula 4]

[264] $1.1 < C1 < 1.4$

[265] [Formula 5]

[266] $-0.3 < C2 < +0.3$

[267] According to an embodiment, the camera module may satisfy the following Formula 6.

[268] [Formula 6]

[269] $25 < Vd_1 < 95$

[270] (where Vd_1 is an Abbe number of the reflective and refractive member.)

[271] According to an embodiment, the incident surface and the exit surface of the reflective and refractive member may be coated with a material that reduces reflectivity.

[272] According to an embodiment, the incident surface and the exit surface of the reflective and refractive member may be coated with a material that blocks 80% or more of light having a wavelength of 700nm or more.

[273] According to an embodiment, the camera module may satisfy the following Formula 7.

[274] [Formula 7]

[275] $5° < FOV < 35°$

[276] (where FOV (field of view) is a field of view of the camera module.)

[277] According to an embodiment, the lens assembly or the image sensor may be configured to perform a focus adjustment function by moving along an optical axis O-I.

[278] According to an embodiment, the lens assembly or the image sensor may be configured to perform an anti-shake function by moving along a direction perpendicular to the optical axis O-I.

[279] According to an embodiment, the camera module may be configured to perform an anti-

may be configured to totally reflect at least a portion of light incident on the reflective and refractive member by satisfying the following Formula 9, Formula 10, Formula 11, Formula 12, and Formula 13 regarding a TRF inside the reflective and refractive member 300, 400, 500, 500', 600, 600', 700, 700', or 800.

[290] [Formula 9]

[291] $$TRF = \frac{C1 + b}{2a - C2}$$

[292] (where a is an angle between the first surface and the second surface adjacent to the first surface, b is an incident angle of light incident on the reflective and refractive member, and C1 and C2 are a coefficient of a linear equation and a constant, respectively, when an inverse sine function for a reciprocal of a refractive index of the reflective and refractive member is expressed as a linear equation for the reciprocal of refractive index of the reflective and refractive member.)

[293] [Formula 10]

[294] $10° < a < 50°$

[295] [Formula 11]

[296] $b < 45°$

[297] [Formula 12]

[298] $1.1 < C1 < 1.4$

[299] [Formula 13]

[300] $-0.3 < C2 < +0.3$

[301] According to an embodiment, the electronic device may satisfy the following Formula 14.

[302] [Formula 14]

[303] $25 < Vd_1 < 95$

[304] (where Vd_1 is an Abbe number of the reflective and refractive member.)

[305] According to an embodiment, the electronic device may satisfy the following Formula 15.

[306] [Formula 7]

[307] $5° < FOV < 35°$

[308] (where FOV (field of view) is a field of view of the camera module.)

[309] According to an embodiment, the reflective and refractive member may include a glass material.

[310] According to an embodiment, the electronic device may satisfy the following Formula 16.

[311] [Formula 16]

[312] $p1 \leq EIA \leq p2$

[313] (where EIA (effective incident area) is an effective incident area, p1 is a first end of the first area 8011 corresponding to the effective incident area, and p2 is a second end of the first area 8011 corresponding to the effective incident area.)

[314] The effects obtainable from the disclosure are not limited to the effects mentioned above, and other effects not mentioned will be clearly understood by those skilled in the art.

[315] Although the disclosure has been illustrated and described with respect to an embodiment, it should be understood that the embodiment is intended to be illustrative and not to limit the disclosure. It will be apparent to those skilled in the art that various changes in form and detail may be made without departing from the overall scope of the disclosure, including the appended claims and their equivalents.

【CLAIMS】

【Claim 1】

A camera module (100) comprising:

a lens assembly (200);

at least one reflective and refractive member (300; 400; 500; 500'; 600; 600'; 700; 700'; 800) in which light is reflected and/or refracted at least twice; and

an image sensor (IS),

wherein the reflective and refractive member (300; 400; 500; 500'; 600; 600'; 700; 700'; 800) is configured to totally reflect at least a portion of light incident on the reflective and refractive member by satisfying the following Formula 1, Formula 2, Formula 3, Formula 4, and Formula 5 regarding a refractive index for total reflection inside the reflective and refractive member (300; 400; 500; 500'; 600; 600'; 700; 700'; 800),

[Formula 1]

$$n_i \geq \frac{C1+b}{2a-C2}$$

(where n_i is a refractive index of the reflective and refractive member, a is an angle between an incident surface (301; 401; 501; 501'; 601; 601'; 701; 701'; 801) of the reflective and refractive member and a first reflective surface (302; 402; 502; 502'; 602; 602'; 702; 702'; 802) adjacent to the incident surface, b is an incident angle of light incident on the reflective and refractive member, and C1 and C2 are a coefficient of a linear equation and a constant, respectively, when an inverse sine function for a reciprocal of the refractive index of the reflective and refractive member is expressed as a linear equation for the reciprocal of the of the refractive index reflective and refractive member),

[Formula 2]

$10° < a < 50°$

[Formula 3]

$b < 45$

[Formula 4]

$1.1 < C1 < 1.4$

[Formula 5]

$-0.3 < C2 < +0.3$

【Claim 2】

The camera module of claim 1, wherein the camera module satisfies the following Formula 6,

[Formula 6]

$25 < Vd_1 < 95$

(where Vd_1 is an Abbe number of the reflective and refractive member.)

【Claim 3】

The camera module of claim 1 or 2, wherein the incident surface and an exit surface of the reflective and refractive member are coated with a material that reduces reflectivity.

【Claim 4】

The camera module of any one of claims 1 to 3, wherein the incident surface and the exit surface of the reflective and refractive member are coated with a material that blocks 80% or more of light having a wavelength of 700nm or more.

【Claim 5】

The camera module of any one of claims 1 to 4, wherein the camera module satisfies the following Formula 7,

[Formula 7]

$5° < FOV < 35°$

(where FOV (field of view) is a field of view of the camera module.)

【Claim 6】

The camera module of any one of claims 1 to 5, wherein the lens assembly or the image sensor is configured to perform a focus adjustment function by moving along an optical axis (O-I).

【Claim 7】

The camera module of any one of claims 1 to 6, wherein the lens assembly or the image sensor is configured to perform an anti-shake function by moving along a direction perpendicular to an optical axis (O-I).

【Claim 8】

The camera module of any one of claims 1 to 7, wherein the camera module is configured to perform an anti-shake function through a movement or rotational operation of the reflective and refractive member.

【Claim 9】

The camera module of any one of claims 1 to 8, wherein the reflective and refractive member includes a glass material.

【Claim 10】

The camera module of any one of claims 1 to 9, wherein the camera module satisfies the following Formula 8,

[Formula 8]

$p1 \leq EIA \leq p2$

(where EIA (effective incident area) is an effective incident area, p1 is a first end of a first area (8011) corresponding to the effective incident area, and p2 is a second end of the first area (8011) corresponding to the effective incident area.)

【Claim 11】

The camera module of any one of claims 1 to 10, wherein the camera module is a folded-type camera module.

【Claim 12】

The camera module of any one of claims 1 to 11, wherein a mirror coating is applied to the first reflective surface.

【Claim 13】

The camera module of any one of claims 1 to 12, wherein total reflection occurs on each of the first reflective surface and the incident surface.

【Claim 14】

The camera module of any one of claims 1 to 13, wherein a cut surface is formed at a vertex between the incident surface and the first reflective surface, and/or at a vertex between an

exit surface and a second reflective surface.

【Claim 15】

An electronic device (1701) comprising the camera module of any one of claims 1 to 14.