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(54) **CAMERA MODULE**

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(57) **ABSTRACT**

A camera module includes a lens assembly including a plurality of lenses along a first optical path, and an image sensor including an image surface and provided at one side of the lens assembly, where the plurality of lenses include a first lens including a first hole through a center thereof, a second lens adjacent to an image-side surface of the first lens, the second lens configured as a reflective type lens, and including a second hole through a center thereof, a third lens adjacent to the first lens and configured as a reflective type lens, a fourth lens adjacent to an image-side surface of the third lens, and a fifth lens adjacent to an image-side surface of the fourth lens.

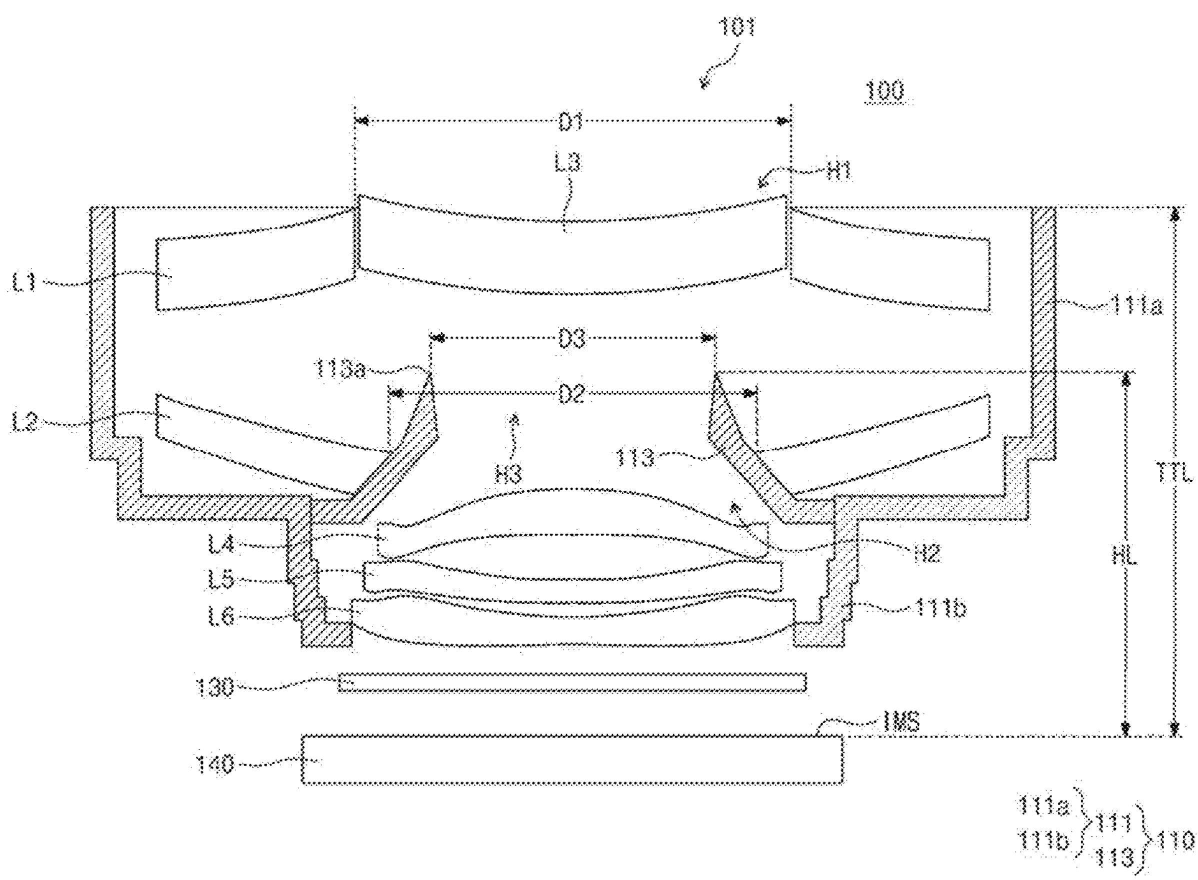


FIG. 1

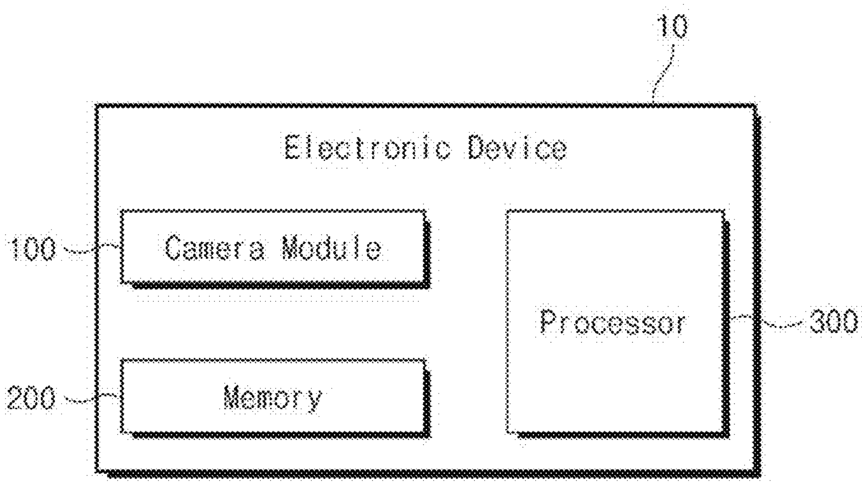

10
Electronic Device
100
Camera Module
200
Memory
Processor
300

FIG. 2

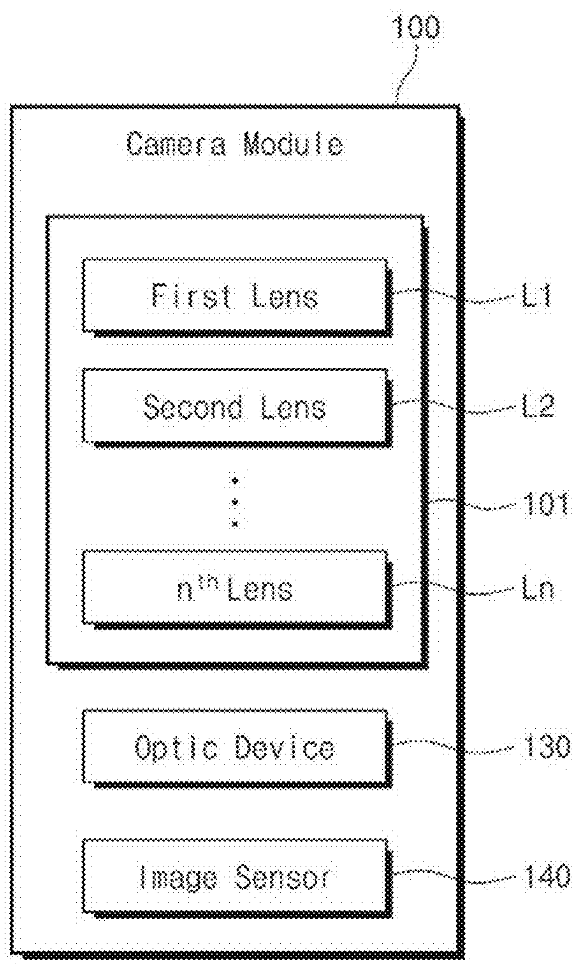

100
Camera Module
First Lens
L1
Second Lens
L2
101
n^th Lens
Ln
Optic Device
130
Image Sensor
140

FIG. 3

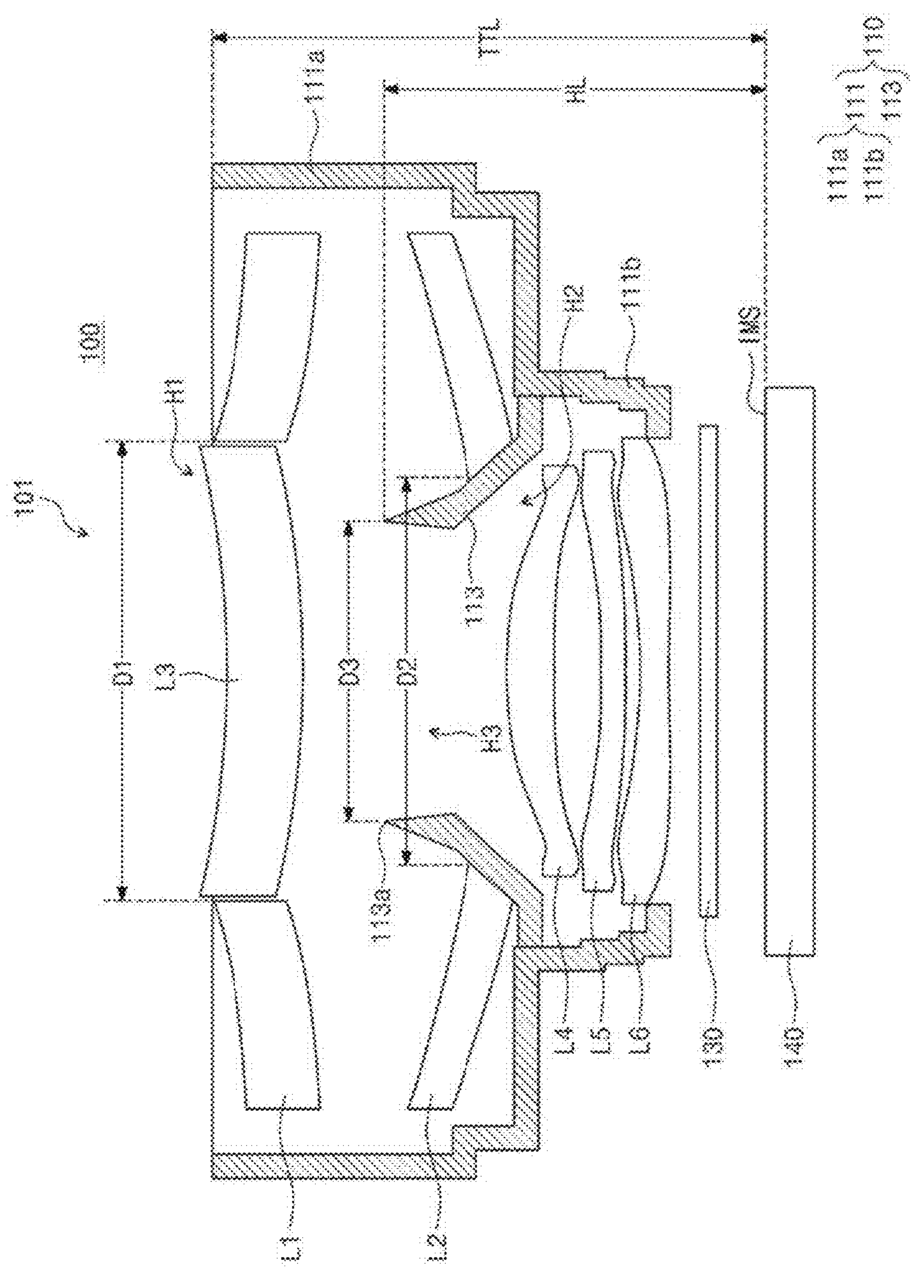

100
101
H1
L3
D1
D2
D3
H3
113
113a
H2
111a
111b
IMS
TTL
HL
111
113
110
L1
L2
L4
L5
L6
130
140

FIG. 4

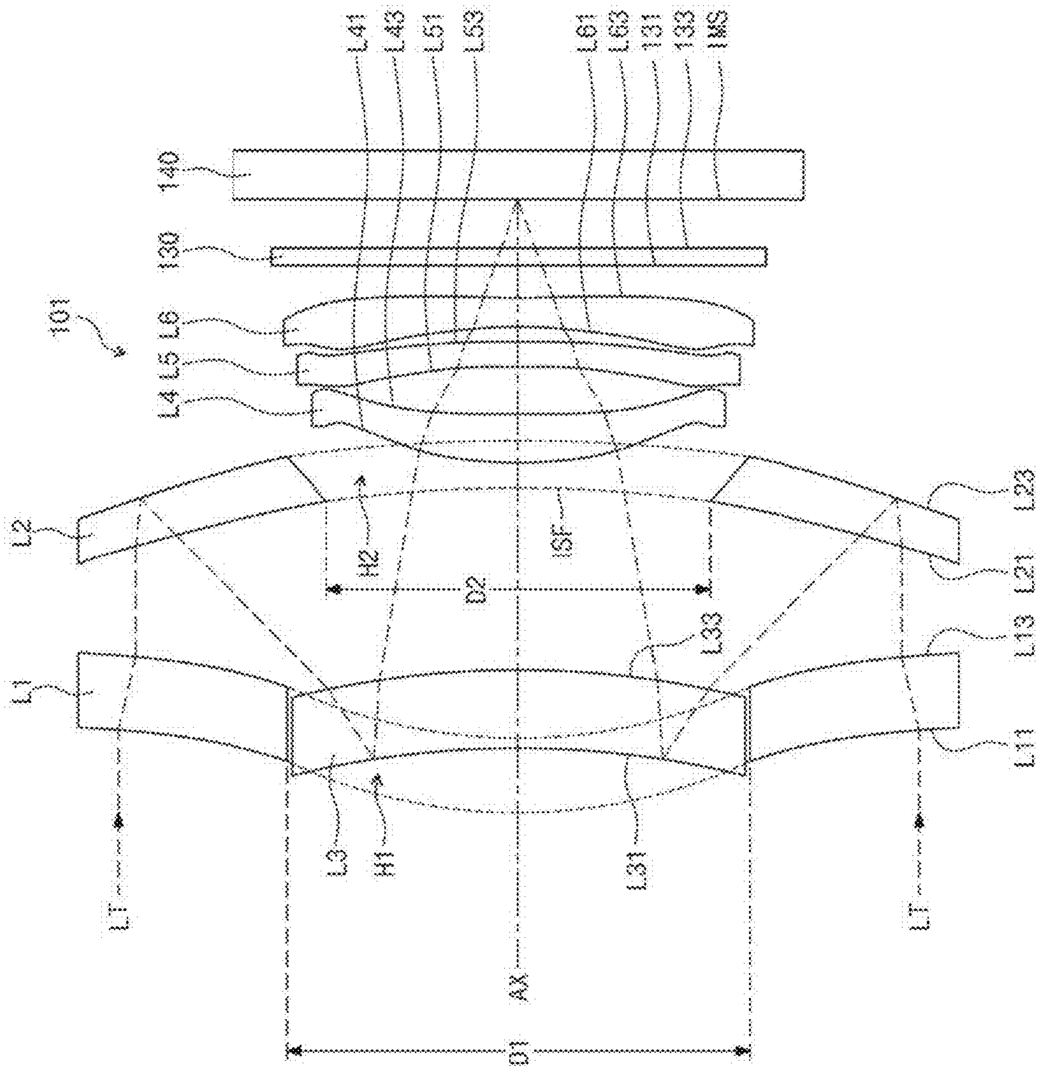
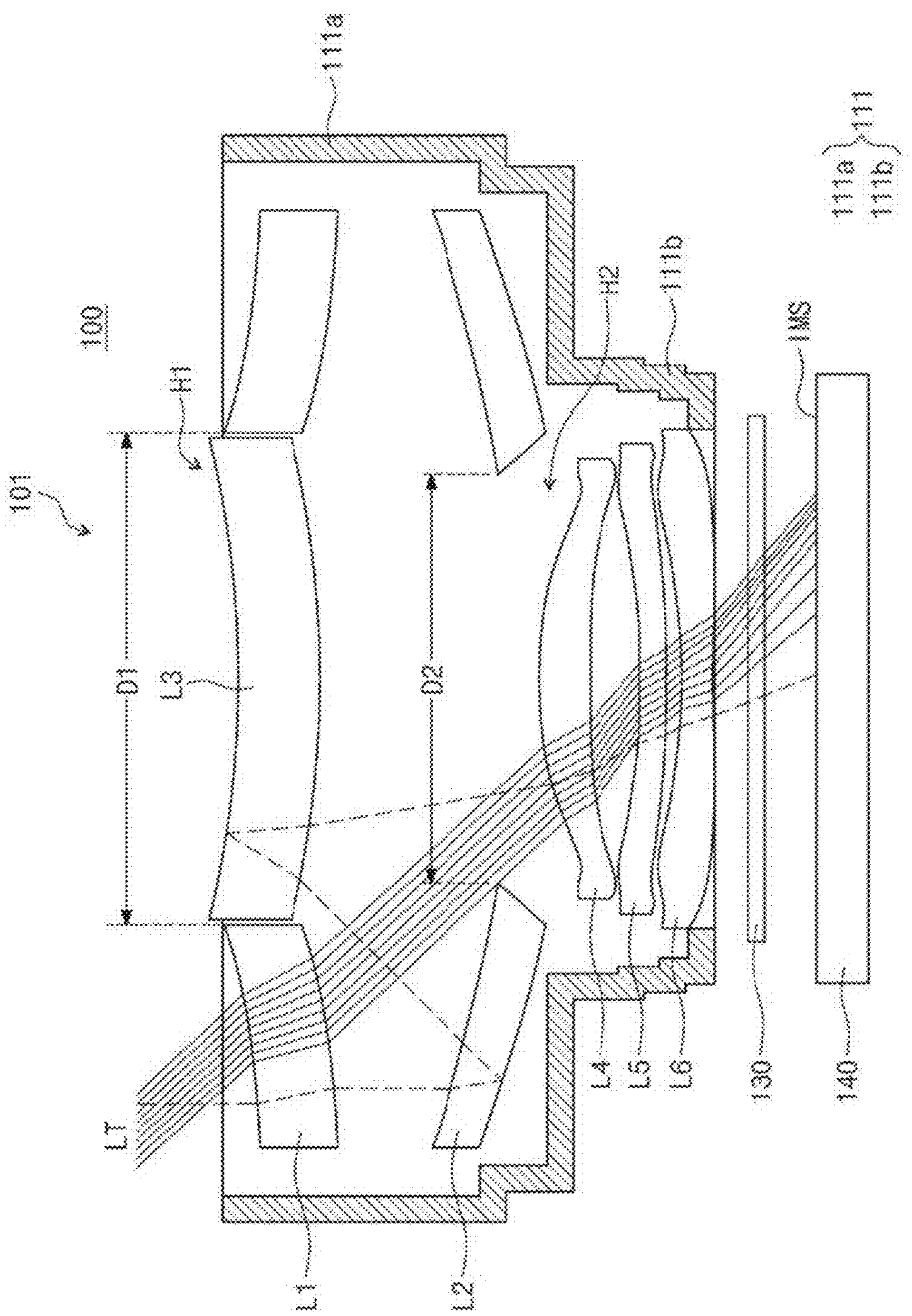

L41
L43
L51
L53
L61
L63
131
133
IMS
140
130
101
L6
L5
L4
L2
L23
L21
H2
D2
ISF
L1
L13
L33
L11
L3
H1
L31
LT
AX
D1

FIG. 5


100
101
H1
D1
L3
D2
H2
111a
111b
111a
111b
111
IMS
LT
L1
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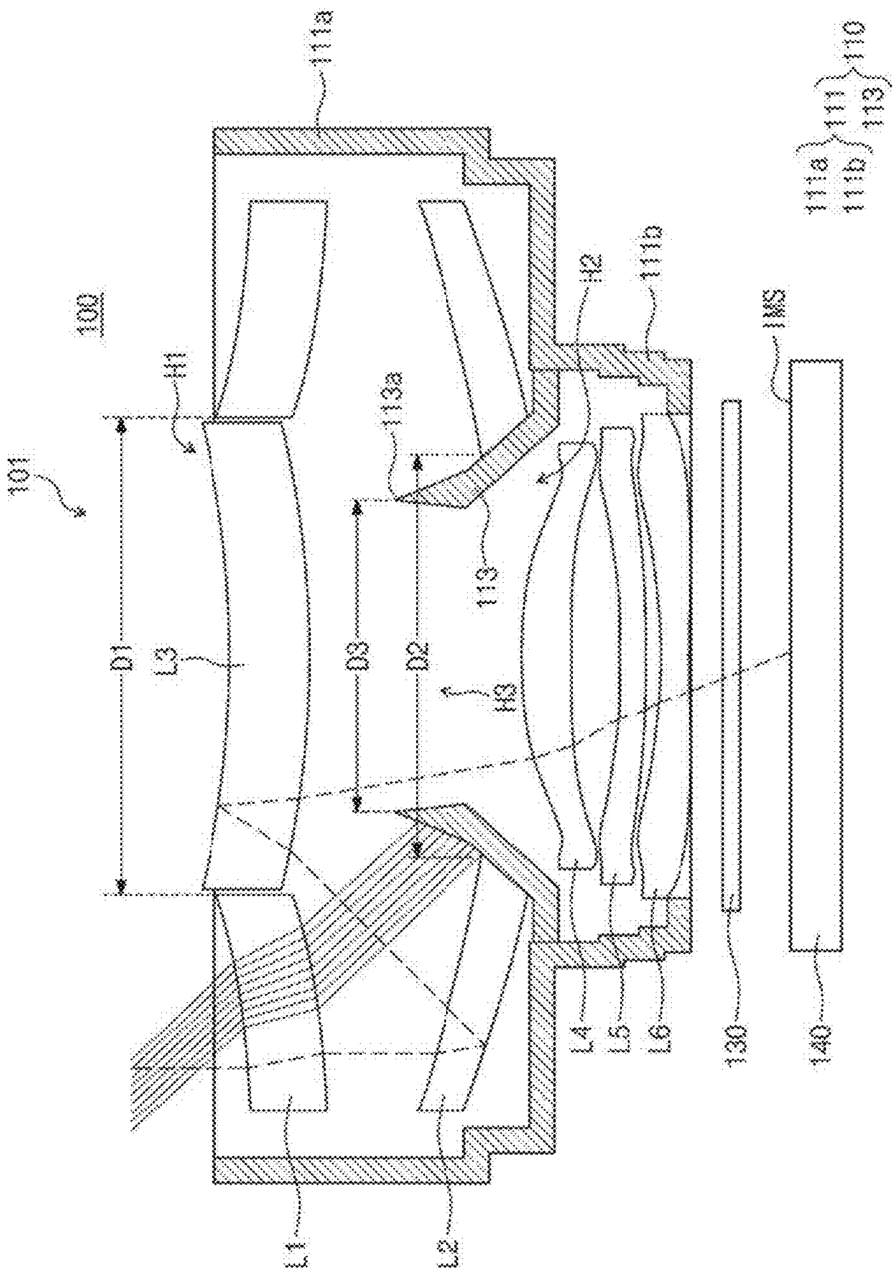
L4
L5
L6
130
140

FIG. 6



101
100
H1
D1
L3
113a
D3
D2
113
H3
H2
111a
111b
IMS
111a
111b
111
113
110
L1
L2
L4
L5
L6
130
140

FIG. 7

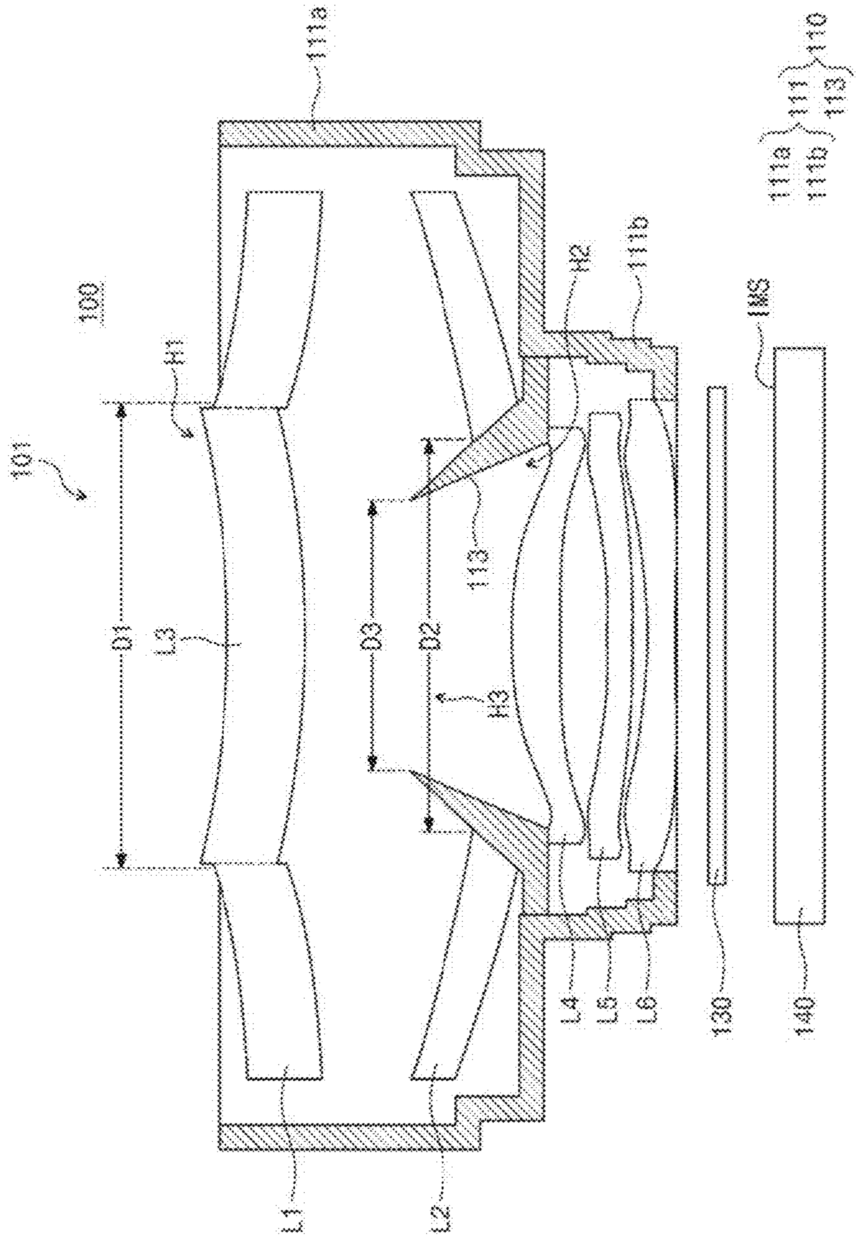
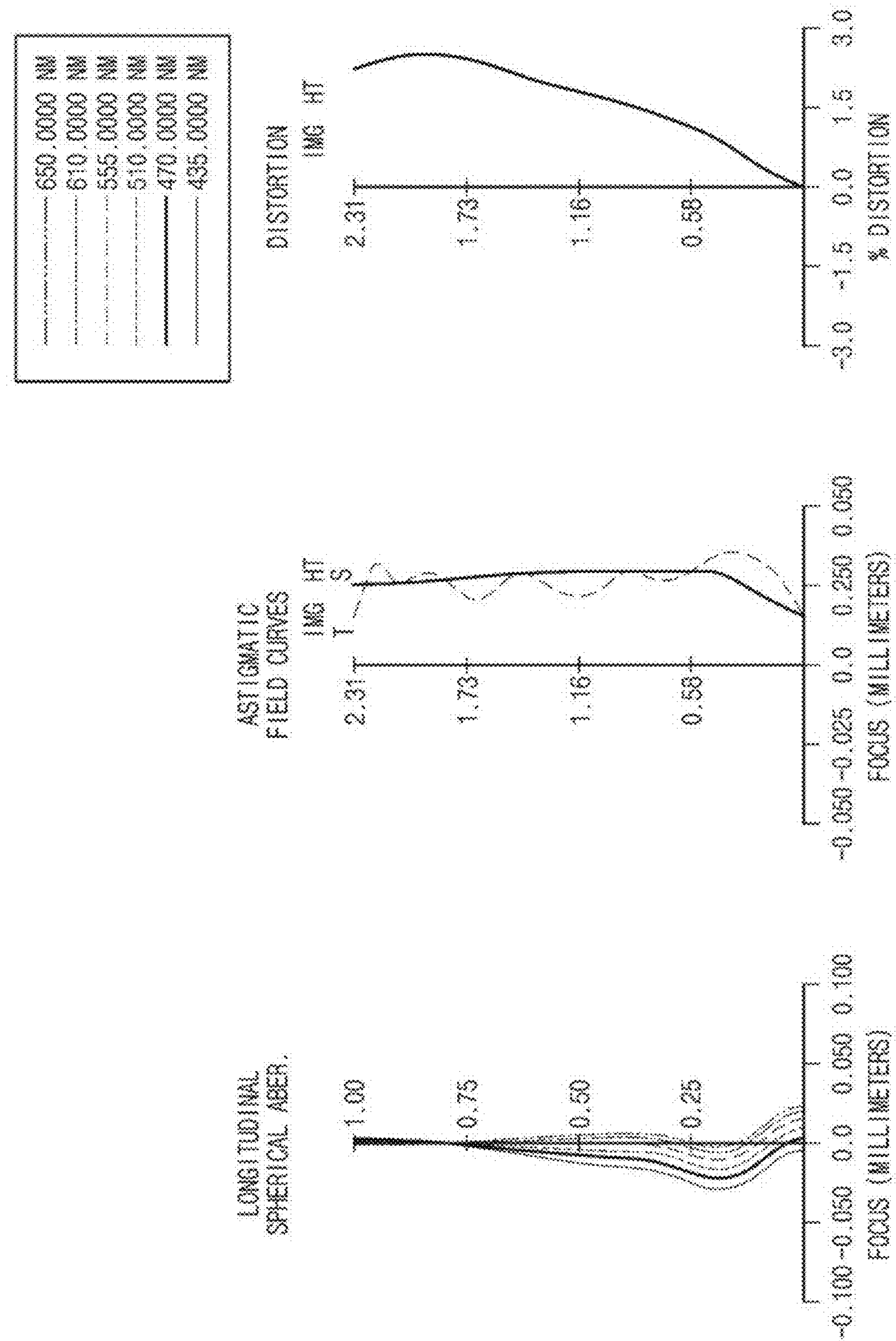

101
100
H1
D1
L3
D3
D2
H3
113
H2
111b
111a
111a
111b
111
113
110
IMS
L1
L2
L4
L5
L6
130
140

FIG. 8


LONGITUDINAL SPHERICAL ABER.
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0.75
0.50
0.25
-0.100 -0.050 0.0 0.050 0.100
FOCUS (MILLIMETERS)
ASTIGMATIC FIELD CURVES
IMG HT
T
S
2.31
1.73
1.16
0.58
-0.050 -0.025 0.0 0.250 0.050
FOCUS (MILLIMETERS)
DISTORTION
IMG HT
2.31
1.73
1.16
0.58
-3.0 -1.5 0.0 1.5 3.0
% DISTORTION
650.0000 NM
610.0000 NM
555.0000 NM
510.0000 NM
470.0000 NM
435.0000 NM

FIG. 9

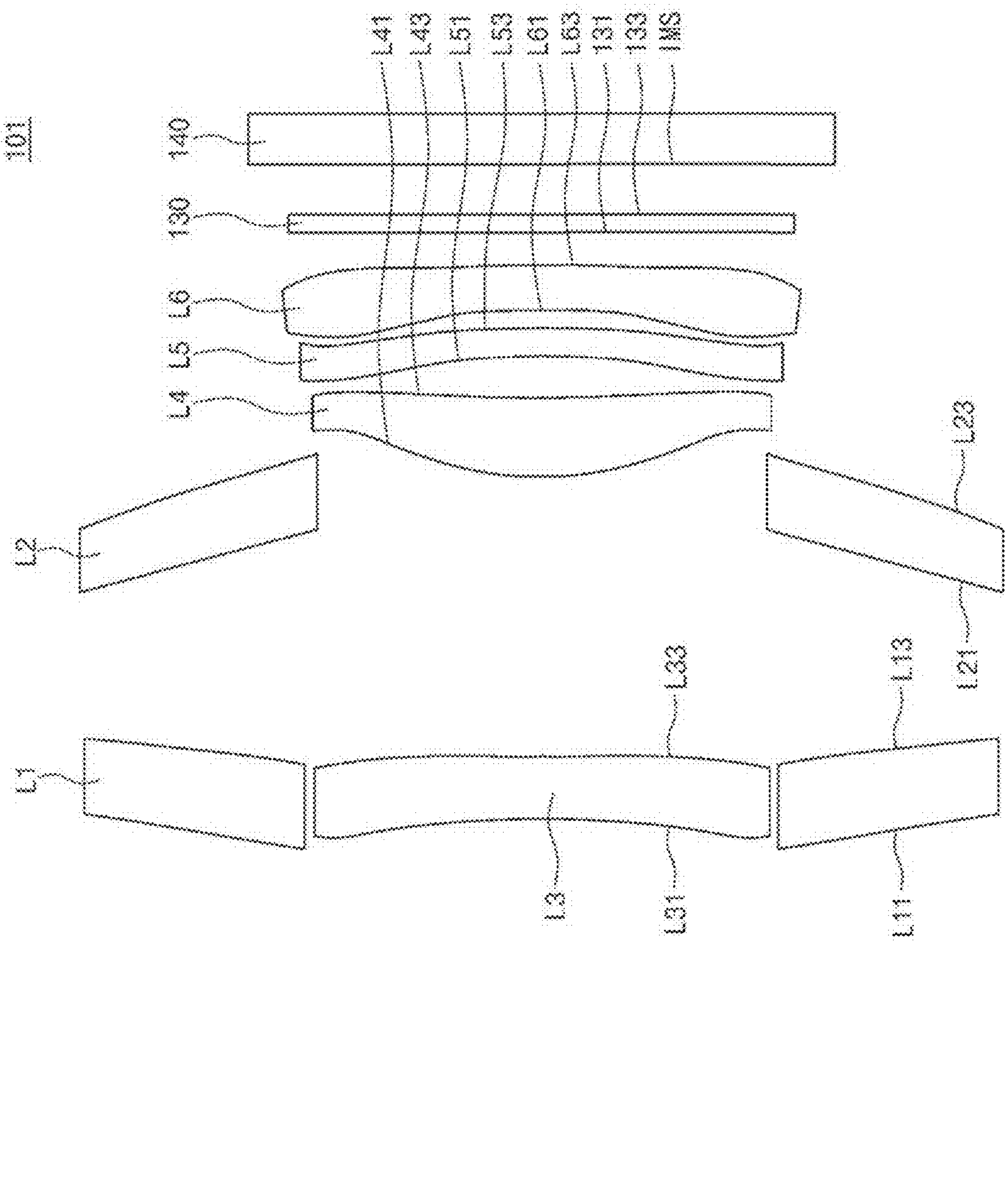

101
L41
L43
L51
L53
L61
L63
131
133
IMS
140
130
L6
L5
L4
L2
L23
L21
L1
L33
L13
L3
L31
L11

FIG. 10

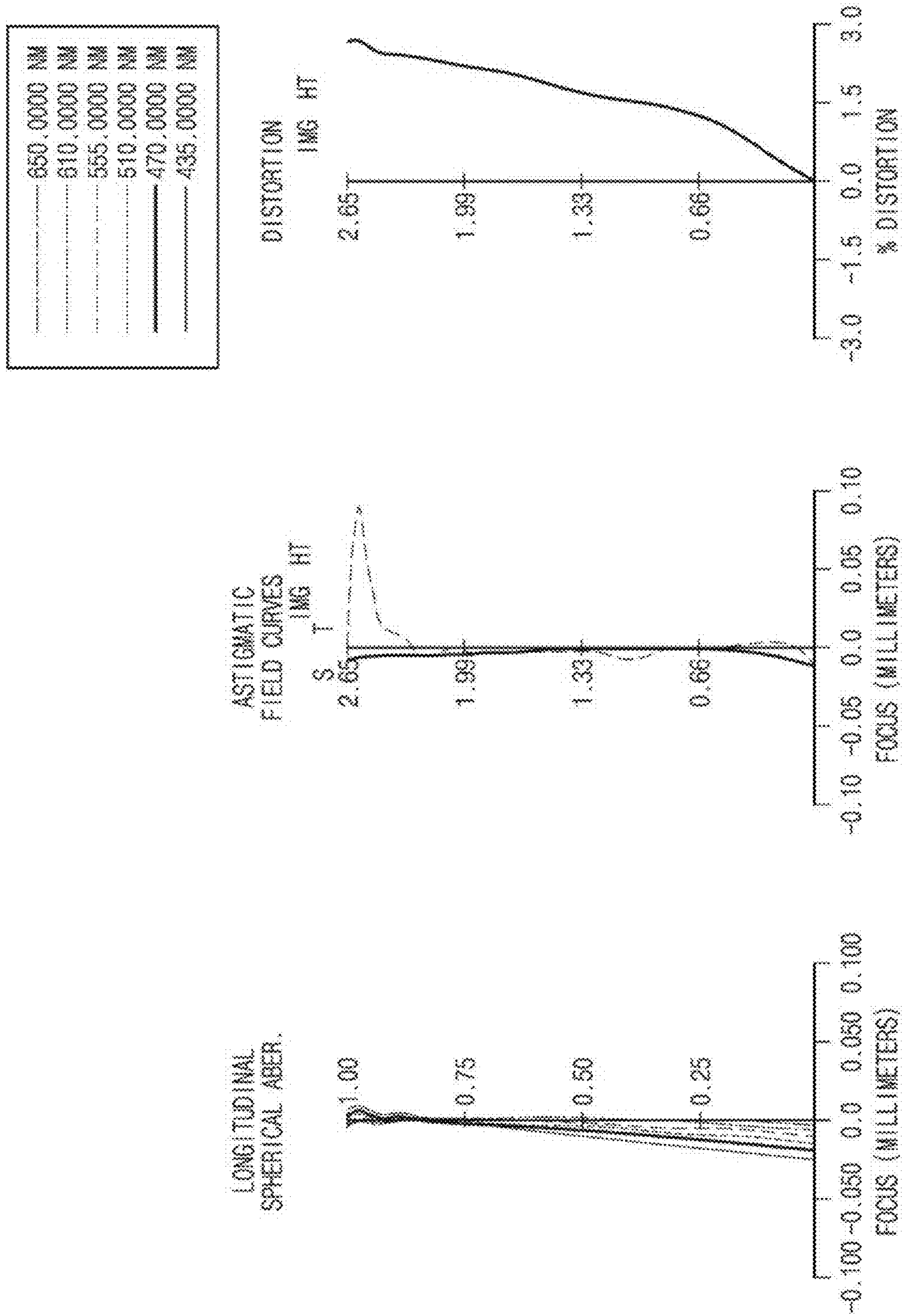

LONGITUDINAL SPHERICAL ABER.
1.00
0.75
0.50
0.25
-0.100 -0.050 0.0 0.050 0.100
FOCUS (MILLIMETERS)
ASTIGMATIC FIELD CURVES
IMG HT
S
T
2.65
1.99
1.33
0.66
-0.10 -0.05 0.0 0.05 0.10
FOCUS (MILLIMETERS)
DISTORTION
IMG HT
2.65
1.99
1.33
0.66
-3.0 -1.5 0.0 1.5 3.0
% DISTORTION
650.0000 NM
610.0000 NM
555.0000 NM
510.0000 NM
470.0000 NM
435.0000 NM

FIG. 11

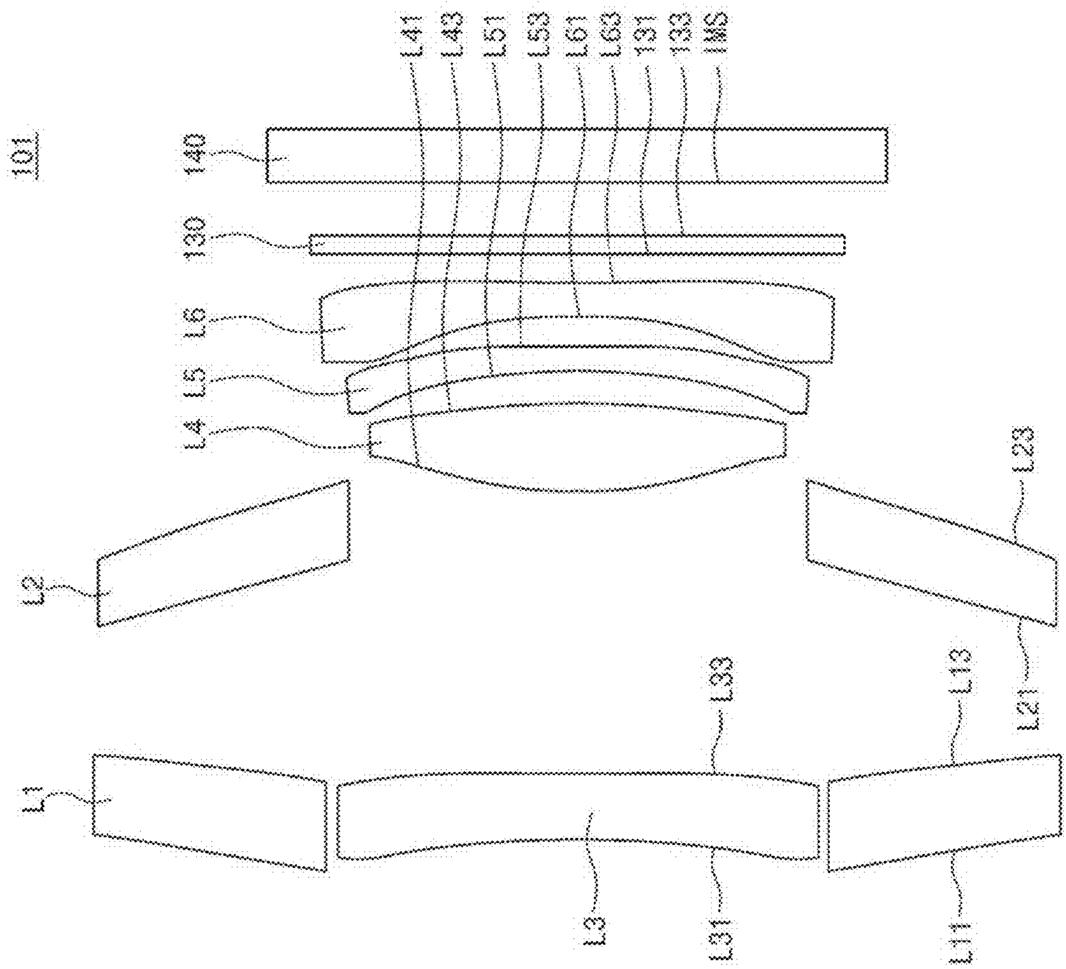
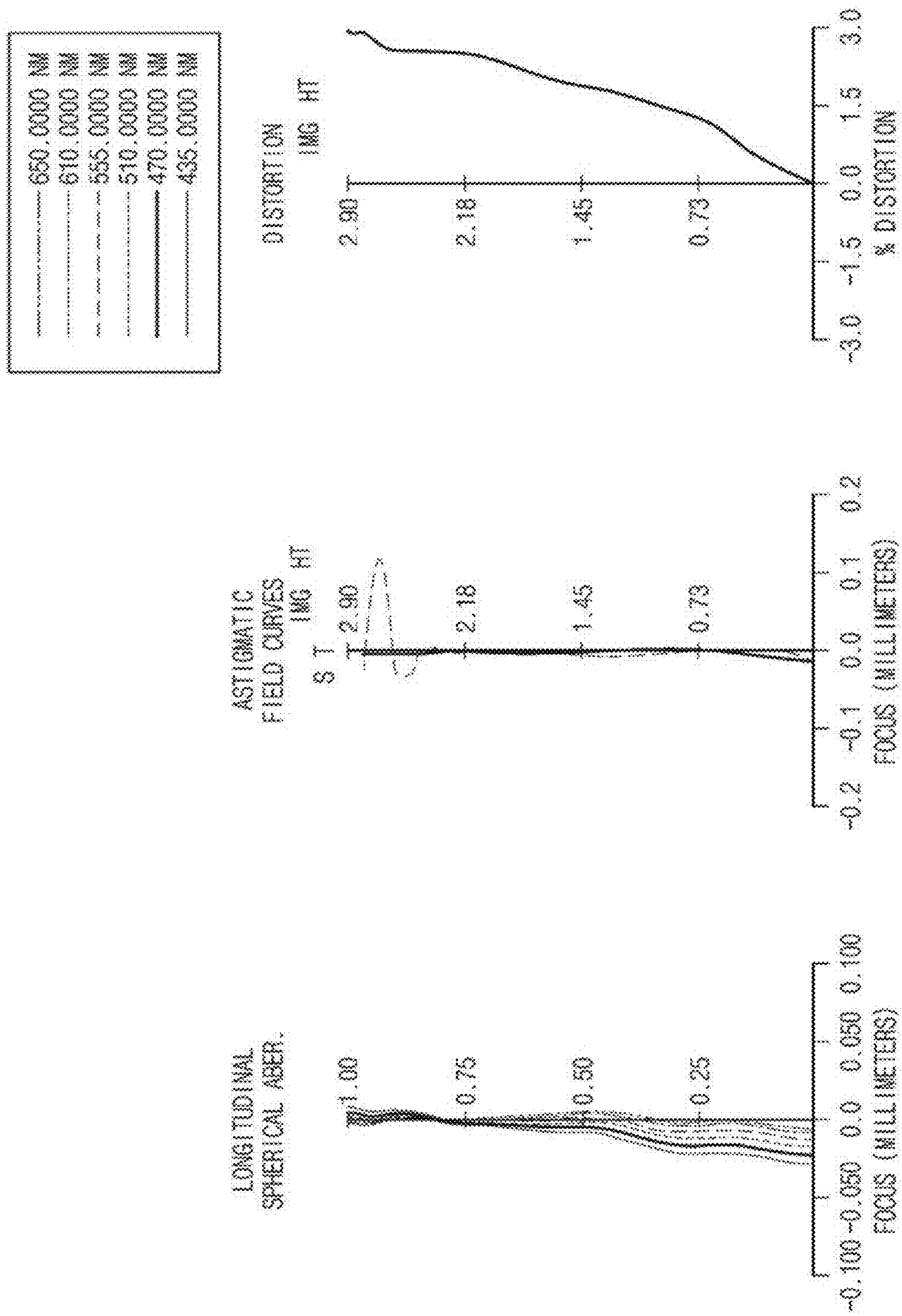

101
L1
L2
L3
L4
L5
L6
L11
L13
L21
L23
L31
L33
L41
L43
L51
L53
L61
L63
130
131
133
140
IMS

FIG. 12


LONGITUDINAL SPHERICAL ABER.
1.00
0.75
0.50
0.25
-0.100 -0.050 0.0 0.050 0.100
FOCUS (MILLIMETERS)
ASTIGMATIC FIELD CURVES
IMG HT
S T
2.90
2.18
1.45
0.73
-0.2 -0.1 0.0 0.1 0.2
FOCUS (MILLIMETERS)
DISTORTION
IMG HT
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2.18
1.45
0.73
-3.0 -1.5 0.0 1.5 3.0
% DISTORTION
650.0000 NM
610.0000 NM
555.0000 NM
510.0000 NM
470.0000 NM
435.0000 NM

CAMERA MODULE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is based on and claims priority to Korean Patent Application No. 10-2024-0024585, filed on Feb. 20, 2024, in the Korean Intellectual Property Office, the disclosure of which is incorporated by reference herein in its entirety.

BACKGROUND

[0002] Example embodiments of the disclosure relate to a camera module including a lens assembly with a plurality of lenses.

[0003] Recently, imaging devices are decreasing in size and are capable of acquiring images that are higher in resolution. Camera modules provided on electronic devices may also be required to have high optical performance and to be small in size. Particularly, in the case of a camera module that is provided on small electronic devices, such as a mobile phone, the camera module may be required to have high magnification characteristics while having a small size.

[0004] However, a total track length (TTL) from a focus to a first lens surface of an optical system may be very short, and thus, an appropriate optical path may not secured, resulting in defects such as flare.

[0005] Information disclosed in this Background section has already been known to or derived by the inventors before or during the process of achieving the embodiments of the present application, or is technical information acquired in the process of achieving the embodiments. Therefore, it may contain information that does not form the prior art that is already known to the public.

SUMMARY

[0006] One or more example embodiments provide a camera module capable of realizing high magnification while being small in size and capable of preventing defects such as flare.

[0007] Additional aspects will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the presented embodiments.

[0008] According to an aspect of an example embodiment, a camera module may include a lens assembly including a plurality of lenses along a first optical path, and an image sensor including an image surface and provided at one side of the lens assembly, where the plurality of lenses may include a first lens including a first hole through a center thereof, a second lens adjacent to an image-side surface of the first lens, the second lens configured as a reflective type lens, and including a second hole through a center thereof, a third lens adjacent to the first lens and configured as a reflective type lens, a fourth lens adjacent to an image-side surface of the third lens, and a fifth lens adjacent to an image-side surface of the fourth lens, and the camera module satisfies $4>f/TTL>0.5$ and $0.75>D1/CA>0.4$, where f corresponds to a total effective focal length of the lens assembly, TTL corresponds to a total track length from an object-side surface of the first lens to the image surface of the image sensor, CA corresponds to an effective diameter of the object-side surface of the first lens, and D**1** corresponds to a diameter of the first hole.

[0009] According to an aspect of an example embodiment, a lens assembly may include a plurality of lenses along an optical path, the plurality of lenses including a first lens including a first hole through a center thereof, a second lens adjacent to an image-side surface of the first lens, the second lens configured as a reflective type lens, and including a second hole through a center thereof, a third lens adjacent to the first lens and configured as a reflective type lens, a fourth lens adjacent to an image-side surface of the third lens, and a fifth lens adjacent to an image-side surface of the fourth lens, and where the lens assembly satisfies $4>f/TTL>0.5$, $0.75>D1/CA>0.4$, and $0.75>D2/CA>0.4$, where f corresponds to a total effective focal length of the lens assembly, TTL corresponds to a total track length from an object-side surface of the first lens to a focus of the lens assembly, CA corresponds to an effective diameter of the object-side surface of the first lens, D**1** corresponds to a diameter of the first hole, and D**2** corresponds to a diameter of the second hole.

[0010] According to an aspect of an example embodiment, an electronic device may include a camera module configured to obtain an image by photographing an object, a processor configured to control the camera module to process the image, and a memory configured to store the image, where the camera module may include a lens assembly including a plurality of lenses along an optical path, and an image sensor including an image surface, where the plurality of lenses may include a first lens including a first hole through a center thereof, a second lens adjacent to an image-side surface of the first lens, the second lens configured as a reflective type lens, and including a second hole through a center thereof, a third lens adjacent to the first lens and configured as a reflective type lens, a fourth lens adjacent to an image-side surface of the third lens, and a fifth lens adjacent to an image-side surface of the fourth lens, and where the camera module satisfies $4>f/TTL>0.5$ and $0.75>D1/CA>0.4$, where f corresponds to a total effective focal length of the lens assembly, TTL corresponds to a length from an object-side surface of the first lens to the image surface of the image sensor, CA corresponds to an effective diameter of the object-side surface of the first lens, and D**1** corresponds to a diameter of the first hole.

BRIEF DESCRIPTION OF DRAWINGS

[0011] The above and other aspects, features, and advantages of certain example embodiments of the present disclosure will be more apparent from the following description taken in conjunction with the accompanying drawings, in which:

[0012] FIG. **1** is a block diagram illustrating an electronic device including a camera module according to one or more embodiments;

[0013] FIG. **2** is a block diagram illustrating a camera module according to one or more embodiments;

[0014] FIG. **3** is a cross-sectional view illustrating a camera module according to one or more embodiments;

[0015] FIG. **4** is a cross-sectional view illustrating a lens assembly, an optic device, and an image sensor of a camera module according to one or more embodiments;

[0016] FIG. **5** is a cross-sectional view illustrating a camera module and illustrating a normal path and an abnormal path of a light incident into the camera module according to one or more embodiments;

[0017] FIG. **6** is a cross-sectional view illustrating a camera module and illustrating a normal path and an abnormal path of a light incident into the camera module according to one or more embodiments;

[0018] FIG. **7** is a cross-sectional view illustrating a camera module according to one or more embodiments;

[0019] FIG. **8** is a graph illustrating a longitudinal spherical aberration, astigmatic field curves, and a distortion aberration of a lens assembly according to one or more embodiments;

[0020] FIG. **9** is a cross-sectional view illustrating a lens assembly according to one or more embodiments;

[0021] FIG. **10** is a graph illustrating a longitudinal spherical aberration, astigmatic field curves, and a distortion aberration of a lens assembly according to one or more embodiments;

[0022] FIG. **11** is a cross-sectional view illustrating a lens assembly according to one or more embodiments; and

[0023] FIG. **12** is a graph illustrating a longitudinal spherical aberration, astigmatic field curves, and a distortion aberration of a lens assembly according to one or more embodiments.

DETAILED DESCRIPTION

[0024] Hereinafter, example embodiments of the disclosure will be described in detail with reference to the accompanying drawings. The same reference numerals are used for the same components in the drawings, and redundant descriptions thereof will be omitted. The embodiments described herein are example embodiments, and thus, the disclosure is not limited thereto and may be realized in various other forms.

[0025] As used herein, expressions such as "at least one of," when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list. For example, the expression, "at least one of a, b, and c," should be understood as including only a, only b, only c, both a and b, both a and c, both b and c, or all of a, b, and c.

[0026] It will be understood that when an element or layer is referred to as being "over," "above," "on," "below," "under," "beneath," "connected to" or "coupled to" another element or layer, it can be directly over, above, on, below, under, beneath, connected or coupled to the other element or layer or intervening elements or layers may be present. In contrast, when an element is referred to as being "directly over," "directly above," "directly on," "directly below," "directly under," "directly beneath," "directly connected to" or "directly coupled to" another element or layer, there are no intervening elements or layers present.

[0027] The present disclosure relates to a camera module including a lens assembly. The camera module is an electronic device that receives a light with a wavelength in a specified range from an external object and generates an image of the external object corresponding to the received light.

[0028] FIG. **1** is a block diagram illustrating an electronic device including a camera module according to one or more embodiments.

[0029] Referring to FIG. **1**, the electronic device **10** may include the camera module **100**, a memory **200**, and a processor **300**.

[0030] The camera module **100** may be provided in singular or plural depending on the electronic device **10**. In one or more embodiments, when the electronic device **10** a mobile phone, the camera module **100** may be provided as a single module or in two or more modules and may be provided on a front surface and/or a rear surface of the mobile phone.

[0031] The camera module **100** may receive a light of various wavelengths, such as a visible light and/or an infrared light, traveling thereto from the outside. The camera module **100** may obtain an image of an external object (i.e., a subject) by generating an electrical signal corresponding to the received light.

[0032] The camera module **100** may transmit the generated image to the processor **300**. In one or more embodiments, the camera module **100** may compress or encode the generated image and may transmit the compressed or encoded image to the processor **300** through a specified interface.

[0033] The memory **200** may store image files, specified files, or specified instructions related to operations performed by the processor **300**. In one or more embodiments, the memory **200** may store the image of an external object or may store instructions related to the operation of the processor **300**, which controls the camera module **100** to generate the image of the external object. The memory **200** may transmit the stored files or instructions to the processor **300** through the specified interface.

[0034] The processor **300** may be electrically connected to components included in the electronic device **10** and may perform operations or data processing related to control and/or communication of the components included in the electronic device **10**. In one or more embodiments, the processor **300** may execute the instructions stored in the memory **200** to process the image obtained by the camera module **100**. In particular, the processor **300** may control the camera module **100** to obtain the image of the external object.

[0035] FIG. **2** is a block diagram illustrating a camera module according to one or more embodiments.

[0036] Referring to FIG. **2**, the camera module **100** may include a lens assembly **101**, an optic device **130**, and an image sensor **140**. The above components of the camera module **100** may be arranged in the order of the lens assembly **101**, the optic device **130**, and the image sensor **140** along a path of a light incident from the outside. According to one or more embodiments, one or more components of the camera module **100** may be omitted, or the camera module **100** may further include components not shown in FIG. **2**. In one or more embodiments, the camera module **100** may further include an image signal process (ISP) to process the image obtained by the image sensor **140** and may further include an interface to transmit data to the processor **300**.

[0037] The lens assembly **101** may include a plurality of lenses, such as n lenses, where n is a natural number equal to or greater than 2. The lenses of the lens assembly **101** may be sequentially arranged along the path of the light incident thereto from the outside and may include a first lens L**1**, a second lens L**2**, . . . , to an n-th lens Ln. In one or more embodiments, the number of the lenses included in the lens assembly **101** may be six, however, embodiments are not limited thereto. For example, the camera module **100** may include one lens assembly **101**. According to one or more embodiments, the camera module **100** may include two or more lens assemblies.

[0038] The lenses of the lens assembly **101** may condense the light incident thereto from the outside. In one or more embodiments, the lenses of the lens assembly **101** may refract and reflect the light incident thereto to condense the light on a predetermined position in the image sensor **140**. The refracted and reflected light may be condensed on the predetermined position in the image sensor **140** after passing through the optic device **130**.

[0039] The image sensor **140** may generate an image (or image data) corresponding to the light passing through the optic device **130**. The image sensor **140** may include a plurality of pixels. The pixels may generate an electrical signal (e.g., a current) that is the basis of the image in response to the received light. The image generated based on the electrical signal may be transmitted to the processor **300** through the specified interface.

[0040] FIG. **3** is a cross-sectional view illustrating a camera module according to one or more embodiments. FIG. **4** is a cross-sectional view illustrating a lens assembly, an optic device, and an image sensor of a camera module according to one or more embodiments. FIG. **4** illustrates a camera module without a housing.

[0041] Referring to FIGS. **3** and **4**, the camera module **100** may include the lens assembly **101**, the optic device **130**, the image sensor **140**, and the housing **110**. The housing **110** may accommodate the lens assembly **101**, the optic device **130**, and the image sensor **140** therein.

[0042] According to one or more embodiments, the lens assembly **101**, the optic device **130**, and the image sensor **140** are arranged sequentially in a direction away from the subject. The image sensor **140** may include an image surface IMS on which a light LT incident through the lenses and the optic device **130** is formed.

[0043] As described herein, an image-side may indicate, for example, a direction toward the image surface IMS where the image is formed, and an object-side may indicate a direction toward the object. In addition, an "object-side surface" of a lens may indicate, for example, a left side in FIG. **4**, which corresponds to a surface of the lens facing the object based on an optical axis AX, and an "image-side surface" may indicate a right side in FIG. **4**, which corresponds to a surface of the lens facing the image surface IMS based on the optical axis AX. The image surface IMS may be a surface of an imaging device or a surface of the image sensor **140**.

[0044] The image sensor **140** may be implemented with a charge-coupled device (CCD) or a complementary metal-oxide-semiconductor (CMOS). However, the image sensor **140** is not limited thereto, and in one or more embodiments, the image sensor **140** may be implemented with various devices that convert the image of the object into electrical image signals.

[0045] The lenses of the lens assembly **101** may be arranged sequentially along an optical path from the outside to the image surface IMS of the image sensor **140**. The lens assembly **101** may include, for example, at least two or more lenses. In one or more embodiments, the lens assembly **101** may include first, second, third, fourth, fifth, and sixth lenses L**1**, L**2**, L**3**, LA, L**5**, and L**6** arranged sequentially along the optical path.

[0046] Hereinafter, the lens assembly **101** is described as including six lenses as an example, but embodiments are not limited thereto. In one or more embodiments, the lens assembly **101** may include fewer or more than six lenses.

[0047] The lenses may include transmissive type lenses and reflective type lenses. Each reflective type lens may be a lens of which at least a portion of the lens acts as a reflective surface. The reflective type lens may include the object-side surface or the image-side surface as its reflective surface. As some lenses are provided as the reflective type lenses, a physical arrangement of the first, second, third, fourth, fifth, and sixth lenses L**1**, L**2**, L**3**, LA, L**5**, and L**6** may vary depending on the optical path. According to one or more embodiments, two lenses may be provided as the reflective type lenses and the optical path may vary, and thus, a sufficient optical path may be secured for a high-magnification lens. In particular, a total track length (TTL) from a focus to one surface of the first lens L**1** may decrease, and a value of an effective focal length (Fno) may increase when compared with a case where the first, second, third, fourth, fifth, and sixth lenses L**1**, L**2**, L**3**, L**4**, L**5**, and L**6** are arranged sequentially in a straight line without the reflective type lens. Accordingly, a size of the lens assembly **101** may be reduced, and thus, the camera module **100** may be miniaturized, and a brighter lens may be implemented.

[0048] In one or more embodiments, among the first, second, third, fourth, fifth, and sixth lenses L**1**, L**2**, L**3**, L**4**, L**5**, and L**6**, the first lens L**1**, the fourth lens L**4**, the fifth lens L**5**, and the sixth lens L**6** may be the transmissive type lens, and the second lens L**2** and the third lens L**3** may be the reflective type lens. The first lens L**1**, the fourth lens L**4**, the fifth lens L**5**, and the sixth lens L**6** that are the transmissive type lens may be arranged sequentially along the optical axis AX from the object (subject) to the image surface IMS of the image sensor **140**. The second lens L**2** and the third lens L**3** that are the reflective type lens may be arranged sequentially along the optical axis AX from the object (subject) to the image surface IMS of the image sensor **140**, and may be arranged adjacent to the transmissive type lenses to surround the transmissive type lenses.

[0049] The first lens L**1** may have a positive refractive power. The first lens L**1** may include an object-side surface L**11** and an image-side surface L**13**, which face opposite directions, respectively. The object-side surface L**11** of the first lens L**1** may face the object (subject), and the image-side surface L**13** of the first lens L**1** may face the image surface IMS of the image sensor **140**. The first lens L**1** may be provided in a ring shape with a first hole H**1** penetrating a center thereof. The first hole H**1** may have a first diameter D**1**.

[0050] The image-side surface L**13** of the first lens L**1** may have a concave shape. In one or more embodiments, the object-side surface L**11** of the first lens L**1** may have a convex shape, and the image-side surface L**13** of the first lens L**1** may have the concave shape. The first lens L**1** may be a spherical lens or an aspherical lens. When the first lens L**1** is the spherical lens, the object-side surface L**11** and the image-side surface L**13** of the first lens L**1** may be spherical, and when the first lens L**1** is the aspherical lens, the object-side surface L**11** and the image-side surface L**13** of the first lens L**1** may be aspherical. The first lens L**1** may be formed of, for example, a glass or plastic material.

[0051] The second lens L**2** may include an object-side surface L**21** and an image-side surface L**23**, which face opposite directions, respectively. The object-side surface L**21** of the second lens L**2** may face the object (subject), and the image-side surface L**23** of the second lens L**2** may face the image surface IMS of the image sensor **140**. The image-side surface L**23** of the second lens L**2** may have a convex shape. In one or more embodiments, the object-side surface L**21** of the second lens L**2** may have a concave shape, and the image-side surface L**23** of the second lens L**2** may have the convex shape.

[0052] The second lens L**2** may be the reflective type lens, and the -image-side surface L**23** of the second lens L**2** may include the reflective surface. The image-side surface L**23** of the second lens L**2** may reflect a light incident thereto from the object-side surface L**21** of the second lens L**2** to the third lens L**3**. The second lens L**2** may be provided in a ring shape with a second hole H**2** penetrating through a center thereof. The second hole H**2** may have a second diameter D**2**.

[0053] The second lens L**2** may be a spherical or aspherical lens. In one or more embodiments, the object-side surface L**21** and the image-side surface L**23** of the second lens L**2** may be aspherical. The second lens L**2** may be formed of, for example, a plastic material.

[0054] The third lens L**3** may be disposed adjacent to the first lens L**1**. The third lens L**3** may include an object-side surface L**31** and an image-side surface L**33**, which face opposite directions, respectively. The object-side surface L**31** of the third lens L**3** may face the object (subject), and the image-side surface L**33** of the third lens L**3** may face the image surface IMS of the image sensor **140**. The object-side surface L**31** of the third lens L**3** may have a concave shape. In one or more embodiments, the object-side surface L**31** of the third lens L**3** may have a concave shape, and the image-side surface L**33** of the third lens L**3** may have a convex shape.

[0055] The third lens L**3** may be the reflective type lens, and the object-side surface

[0056] L**31** of the third lens L**3** may include the reflective surface. The object-side surface L**31** of the third lens L**3** may reflect a light incident thereto from the image-side surface L**33** of the third lens L**3** to the fourth lens L**4**.

[0057] The third lens L**3** may be a spherical or aspherical lens. In one or more embodiments, the object-side surface L**31** and the image-side surface L**33** of the third lens L**3** may be aspherical. The third lens L**3** may be formed of, for example, a plastic material.

[0058] The third lens L**3** may be disposed to overlap the first hole H**1** of the first lens L**1** in a direction substantially parallel to the optical axis AX of the camera module **100**. The third lens L**3** may entirely overlap the first hole H**1** in the direction substantially parallel to the optical axis AX, and in one or more embodiments, the third lens L**3** may be disposed in the first hole H**1**. In this case, the third lens L**3** may have a diameter equal to or smaller than the first diameter D**1** so that the third lens L**3** is disposed in the first hole H**1**.

[0059] According to one or more embodiments, the first lens L**1** and the third lens L**3** may be provided as separate lenses.

[0060] The fourth lens L**4** may have a negative refractive power. The fourth lens LA may include an object-side surface L**41** and an image-side surface L**43**, which face opposite directions, respectively. The object-side surface L**41** of the fourth lens LA may face the object (subject), and the image-side surface L**43** of the fourth lens L**4** may face the image surface IMS of the image sensor **140**. The image-side surface L**43** of the fourth lens L**4** may have a concave shape. In one or more embodiments, the object-side surface LA**1** of the fourth lens L**4** may have a convex shape, and the image-side surface L**43** of the fourth lens L**4** may have a concave shape. The fourth lens L**4** may be an aspherical lens, and the object-side surface L**41** and the image-side surface L**43** of the fourth lens L**4** may be aspherical. The fourth lens L**4** may be formed of, for example, a plastic material.

[0061] The fourth lens L**4** may be disposed to overlap at least a portion of the second hole H**2** of the second lens L**2** in the direction substantially parallel to the optical axis AX or may be disposed adjacent to the second hole H**2** without overlapping the second hole H**2**. In one or more embodiments, the fourth lens L**4** may overlap the second hole H**2**. In one or more embodiments, the fourth lens L**4** may be disposed in the second hole H**2**. However, the fourth lens L**4** may be provided in a position biased toward the image sensor **140** rather than inside the second hole H**2**. FIG. **4** shows a structure in which the fourth lens L**4** partially overlaps the second hole H**2** of the second lens L**2**.

[0062] The fifth lens L**5** may have the positive refractive power. The fifth lens L**5** may include an object-side surface L**51** and an image-side surface L**53**, which face opposite directions, respectively. The object-side surface L**51** of the fifth lens L**5** may face the object (subject), and the image-side surface L**53** of the fifth lens L**5** may face the image surface IMS of the image sensor **140**. The image-side surface L**53** of the fifth lens L**5** may have a convex shape. In one or more embodiments, the object-side surface L**51** of the fifth lens L**5** may have a concave shape, and the image-side surface L**53** of the fifth lens L**5** may have a convex shape. The fifth lens L**5** may be an aspherical lens, and the object-side surface L**51** and the image-side surface L**53** of the fifth lens L**5** may be aspherical. The fifth lens L**5** may be formed of, for example, a plastic material.

[0063] The sixth lens L**6** may have the negative refractive power. The sixth lens L**6** may include an object-side surface L**61** and an image-side surface L**63**, which face opposite directions, respectively. The object-side surface L**61** of the sixth lens L**6** may face the object (subject), and the image-side surface L**63** of the sixth lens L**6** may face the image surface IMS of the image sensor **140**. The image-side surface L**63** of the sixth lens L**6** may have a convex shape. In one or more embodiments, the object-side surface L**61** of the sixth lens L**6** may have a concave shape, and the image-side surface L**63** of the sixth lens L**6** may have a convex shape. The sixth lens L**6** may be an aspherical lens, and the object-side surface L**61** and the image-side surface L**63** of the sixth lens L**6** may be aspherical. The sixth lens L**6** may be formed of, for example, a plastic material. The sixth lens L**6** may be omitted.

[0064] The optic device **130** may be disposed between the sixth lens L**6** and the image surface IMS of the image sensor **140**. The optic device **130** may be a filter that blocks some wavelengths of the light LT incident thereto that travels through the first, second, third, fourth, fifth, and sixth lenses L**1**, L**2**, L**3**, L**4**, L**5**, and L**6**. In one or more embodiments, in a case where the image to be obtained by the image sensor **140** is a visible light image, the optic device **130** may be an infrared blocking filter that blocks an infrared wavelength of the light LT. When the infrared blocking filter is used as the optic device **130**, the optic device **130** may transmit the visible light and may block the infrared light, and thus, the infrared light may not reach the image surface IMS. According to one or more embodiments, in a case where the image to be obtained by the image sensor **140** is an infrared light image, the optic device **130** may be omitted, and the lens assembly **101** may be implemented without the optic device **130**.

[0065] As described above, at least one lens of the lens assembly **101** may be formed of a plastic material. According to one or more embodiments, the lens assembly **101** may include at least three plastic lenses. In one or more embodiments, all lenses included in the lens assembly **101** may be plastic lenses. Accordingly, the lens assembly **101** may be lightweight and production costs may be reduced.

[0066] According to the arrangement of the lenses described above, the light LT from the subject may travel toward the optic device **130** and the image sensor **140** through the first, second, third, fourth, fifth, and sixth lenses L**1**, L**2**, L**3**, L**4**, L**5**, and L**6**. The optical path of the light LT within the lens assembly **101** is indicated by a dotted line. The camera module **100** may be configured to increase a length of the optical path of the light LT incident into the camera module **100** without increasing an overall length of the camera module **100**. In one or more embodiments, the light LT from the outside may be incident into the object-side surface L**21** of the second lens L**2** through the first lens L**1**, may be reflected by the image-side surface L**23** of the second lens L**2**, and then may be incident into the image-side surface L**33** of the third lens L**3**. The light LT may be incident into the fourth lens L**4** after being reflected by the object-side surface L**31** of the third lens L**3** and may be incident into the image surface IMS of the image sensor **140** through the third, fourth, and fifth lenses L**3**, L**4**, and L**5** and the optic device **130**.

[0067] As described above, the light exiting from the lens assembly **101** may reach the image sensor **140** after passing through the optic device **130**.

[0068] When the light reaches the image sensor **140**, the image sensor **140** may obtain the image from the light LT. The image sensor **140** may include the pixels that convert the light LT incident thereto through the first, second, third, fourth, fifth, and sixth lenses L**1**, L**2**, L**3**, LA, L**5**, and L**6** and the optic device **130** into the electrical signals to obtain the image. According to one or more embodiments, the image sensor **140** may be attached to a printed circuit board (PCB). The image sensor **140** may be electrically connected to the processor **300** via the PCB and may transmit the obtained image to the processor **300**.

[0069] In one or more embodiments, the lenses of the lens assembly may satisfy predetermined conditions described below to realize the high magnification while being small in size.

[0070] The first lens L**1** may act as an aperture within the camera module **100**. The first lens L**1** may have a same size (e.g., a same diameter) or a greater size than each of the second, third, fourth, fifth, and sixth lenses L**2**, L**3**, LA, L**5**, and L**6**.

[0071] In addition, the first lens L**1** may have the largest effective diameter within the camera module **100**. The effective diameter may refer to a diameter of a lens (or a reflective member) through which a light actually passes. In one or more embodiments, the effective diameter of the object-side surface of the first lens L**1** may be greater than an effective diameter of each of the second, third, fourth, fifth, and sixth lenses L**2**, L**3**, LA, L**5**, and L**6**. In addition, the effective diameter of the object-side surface L**11** of the first lens L**1** and a diagonal length of the image surface IMS of the image sensor **140** may satisfy Equation (1).

$$3 > CA/DG > 0.5 \tag{1}$$

[0072] In Equation (1), CA denotes the effective diameter of the object-side surface of the first lens L**1**, and DG denotes the diagonal length of the image surface IMS of the image sensor **140**.

[0073] The first diameter D**1** of the first hole H**1** of the first lens L**1** may be greater than the diameter of the third lens L**3**. Accordingly, the third lens L**3** may be disposed in the first hole H**1**. The second diameter D**2** of the second hole H**2** of the second lens L**2** may be greater than a diameter of the fourth lens LA. Accordingly, a portion or all of the fourth lens LA may be disposed in the second hole H**2**, or the fourth lens LA may be disposed adjacent to the second hole H**2**.

[0074] The first hole H**1** may have a size that satisfies Equation (2).

$$0.75 > D1/CA > 0.4 \tag{2}$$

[0075] In Equation (2), CA denotes the effective diameter of the object-side surface L**11** of the first lens L**1**, and D**1** denotes the first diameter. When the size of the first hole H**1** is smaller than about 0.4 times of the effective diameter of the object-side surface L**11** of the first lens L**1**, an amount of light traveling toward the second lens L**2** may be large, but an amount of light reflected by the third lens L**3** may be excessively small. In addition, when the size of the first hole H**1** is greater than about 0.75 times of the effective diameter of the object-side surface L**11** of the first lens L**1**, an amount of light incident into the first lens L**1** and traveling toward the second lens L**2** may be reduced, making it difficult to obtain the image.

[0076] Further, the second hole H**2** may be defined through the second lens L**2** to have a predetermined size, and in one or more embodiments, the size of the second hole H**2** may satisfy Equation (3).

$$0.75 > D2/CA > 0.4 \tag{3}$$

[0077] In Equation (3), CA denotes the effective diameter of the object-side surface L**11** of the first lens L**1**, and D**2** denotes the second diameter. When the size of the second hole H**2** is smaller than about 0.4 times of the effective diameter of the object-side surface L**11** of the first lens L**1**, an amount of light reflected by the second lens L**2** and traveling toward the third lens L**3** may be large, but an amount of light reflected by the third lens L**3** and traveling toward the fourth lens LA may be excessively small. In addition, when the size of the second hole H**2** is greater than about 0.75 times of the effective diameter of the object-side surface L**11** of the first lens L**1**, the amount of the light reflected by the second lens L**2** may be reduced.

[0078] According to one or more embodiments, the lens assembly **101** may satisfy Equation (4).

$$4 > f/TTL > 0.5 \tag{4}$$

[0079] In Equation (4), f denotes a total effective focal length of the lens assembly **101**, and TTL denotes the length from the object-side surface L**11** of the first lens L**1** to the image surface IMS of the image sensor **140** on the optical axis AX. When a focus is on the image surface IMS of the image sensor **140**, TTL corresponds to a length from the object-side surface L**11** of the first lens L**1** to the focus of the lens assembly **101**.

[0080] The camera module **100** may implement an autofocus function by moving the first, second, third, fourth, fifth, and sixth lenses L**1**, L**2**, L**3**, LA, L**5**, and L**6**. In one or more embodiments, the camera module **100** may implement the autofocus function by moving the first, second, third, fourth, fifth, and sixth lenses L**1**, L**2**, L**3**, LA, L**5**, and L**6** in a direction substantially parallel to the optical axis AX.

[0081] The housing **110** may accommodate the lens assembly **101** therein. The housing **110** may include a cylindrical portion **111** that supports the lenses at an edge of the lenses and a hood portion **113** that protrudes from an inner side surface of the cylindrical portion **111** toward the object.

[0082] The cylindrical portion **111** may have at least one stepped portion on which the lenses are placed to support the edge of each lens. The cylindrical portion **111** may have an inner diameter that varies depending on the diameter of each lens. In one or more embodiments, the cylindrical portion **111** may include a first cylindrical portion **111***a* that supports the first lens L**1** and the second lens L**2**, which have a relatively large diameter, and a second cylindrical portion **111***b* that supports the third, fourth, fifth, and sixth lenses L**3**, L**4**, L**5**, and L**6**, which have a relatively small diameter. The cylindrical portion **111** may be provided in a single integral body without being divided into multiple portions, however, embodiments are not limited thereto. According to one or more embodiments, the cylindrical portion **111** may include multiple separated portions and may be provided in an assembled form. In addition, additional portions may be provided to effectively support and secure each lens.

[0083] The hood portion **113** may have a ring shape that protrudes from the inner side surface of the first cylindrical portion **111***a* and/or the second cylindrical portion **111***b* toward a center of the cylindrical portion **111**. The hood portion **113** may be provided with a third hole H**3** defined through a center thereof and having a third diameter D**3**.

[0084] The hood portion **113** may be assembled with the first and/or second cylindrical portions **111***a* and **111***b* after being separately manufactured, however, embodiments are not limited thereto. The hood portion **113** may be integrally provided with the first and/or second cylindrical portions **111***a* and **111***b* without being separated from the first and/or second cylindrical portions **111***a* and **111***b*.

[0085] The hood portion **113** may block the light that is incident through the first lens L**1** from traveling through a path other than a path through which the light is incident into the fourth lens L**4** after being reflected by the second lens L**2** and the third lens L**3**. When the path of the light that is incident into the first lens L**1** and travels to the image sensor **140** after sequentially passing through the second, third, fourth, fifth, and sixth lenses L**2**, L**3**, L**4**, L**5**, and L**6** is referred to as a normal path and a path of the light that is incident into the first lens L**1** and travels to the image sensor **140** by taking a path rather than the normal path is referred to as an abnormal path, the hood portion **113** may block the light traveling through the abnormal path.

[0086] The hood portion **113** may be placed on the abnormal path. In one or more embodiments, the hood portion **113** may be placed on the optical path of the light that goes directly from the first lens L**1** to the fourth lens L**4** win a cross-sectional view. The protruded portion **113***a* of the hood portion **113** may block the light that travels from the first lens L**1** directly to the fourth lens L**4**.

[0087] In a cross-sectional view, the hood portion **113** may extend in a direction toward the third lens L**3** after penetrating the second hole H**2** of the second lens L**2** from the image-side surface L**23** to the object-side surface L**21** to block the light that travels straight to the fourth lens L**4** among the lights passing through the first lens L**1**. In this case, an end of the protruded portion **113***a* of the hood portion **113** may be disposed closer to the object than an imaginary lens surface (ISF**1** indicated by a narrow dotted line) of a portion of the second lens L**2**, which is removed when the second hole H**2** is formed, is.

[0088] In one or more embodiments, the third hole H**3** of the hood portion **113** may have a size and shape that allows the light traveling on the normal path to pass therethrough. In one or more embodiments, when the diameter of the third hole H**3** has the third diameter D**3**, the third diameter D**3** may be equal to or smaller than an effective diameter of the fourth lens L**4**.

[0089] In one or more embodiments, an outer side surface of the hood portion **113** may contact a side surface of the second lens L**2** defining the second hole H**2** or may be disposed adjacent to the side surface defining the second hole H**2** of the second lens L**2** without contacting the side surface of the second lens L**2** defining the second hole H**2**.

[0090] At least a portion of the hood portion **113** may be disposed such that the inner side surface defining the third hole H**3** is inclined with respect to the optical axis AX. Accordingly, the at least the portion of the hood portion **113** may have a funnel shape. At an end portion of the hood portion **113**, which is closest to the third lens L**3**, the diameter of the inner side surface defining the third hole H**3** may decrease in a direction from the object to the image surface IMS. In addition, as shown in FIG. **3**, an intermediate portion of the hood portion **113**, which connects the end close to the third lens L**3**, may have a diameter that increases as a distance from the third lens L**3** increases.

[0091] The inclination of the inner side surface and/or the outer side surface of the hood portion **113** with respect to the optical axis AX may be set differently depending on the path of the light reflected by the second lens L**2** and the third lens L**3**. In one or more embodiments, the inclination of the inner surface and/or the outer surface of the hood portion **113** may be set not to allow the hood portion **113** to be disposed on the path of the light reflected by the second lens L**2** and the third lens L**3** when the light traveling on the normal path is sequentially reflected by the second lens L**2** and the third lens L**3**.

[0092] According to one or more embodiments, a length from the end of the hood portion **113** to the image surface IMS of the image sensor **140** may be defined by Equation (5).

$$TTL \times 0.9 > HL > TTL \times 0.5 \tag{5}$$

[0093] In Equation (5), TTL denotes the length from the object-side surface L**11** of the first lens L**1** to the image surface IMS of the image sensor **140** in the optical axis AX, and HL denotes the length from the protruded portion **113***a* of the hood portion **113** to the image surface IMS of the image sensor **140**. When a length of the hood portion **113** is equal to or smaller than 0.5×TTL, the light traveling on the abnormal path may not be sufficiently blocked, and when the length of the hood portion **113** is equal to or greater than 0.9×TTL, the light traveling on the normal path may be blocked.

[0094] FIG. **5** is a cross-sectional view illustrating a camera module and illustrating a normal path and an abnormal path of a light incident into the camera module. FIG. **6** is a cross-sectional view illustrating a camera module and illustrating a normal path and an abnormal path of a light incident into the camera module according to one or more embodiments.

[0095] Referring to FIG. **5**, in the camera module **100** that does not include the hood portion, a portion (indicated by a dotted line) of the light LT incident into a first lens L**1** may travel sequentially through first, second, third, fourth, fifth, and sixth lenses L**1**, L**2**, L**3**, L**4**, L**5**, and L**6**. However, another portion (indicated by solid lines) of the light LT incident into the first lens L**1** may travel directly to the fourth lens L**4** through a second hole H**2** of the second lens L**2** without passing through the second lens L**2** and the third lens L**3** after passing through the first lens L**1**. Particularly, a light traveling outside an angle of view (i.e., a light that travels at a greater inclination angle with respect to an object-side surface of the first lens L**1** among the lights incident into the first lens L**1**) may have a higher probability of traveling directly to the fourth lens L**4**. The light traveling outside the angle of view may appear as a flare in the image sensor **140** and may deteriorate an image quality. In a case where the light traveling on the abnormal path reaches the image sensor **140** after passing through the second hole H**2**, the image sensor **140** may detect the light passing through the abnormal path and the light passing through the normal path in a substantially simultaneous manner, and thus, the image obtained by the image sensor **140** may be different from an actual original object. As a result, a modulation transfer function (MTF) of the lens assembly may be deteriorated.

[0096] Referring to FIG. **6**, in the camera module **100** in one or more embodiments, a portion (indicated by a dotted line) of the light LT incident into the first lens L**1** may travel sequentially through the first, second, third, fourth, fifth, and sixth lenses L**1**, L**2**, L**3**, L**4**, L**5**, and L**6**. The light traveling outside the angle of view (as indicated by the solid lines) (i.e., the light that travels at a greater inclination angle with respect to the object-side surface of the first lens L**1** among the lights incident into the first lens L**1**) may be blocked by the hood portion **113**, and thus may not travel to the fourth lens LA.

[0097] As described above, in the camera module **100** in one or more embodiments, the light traveling on paths other than the paths passing through all the first, second, third, fourth, fifth, and sixth lenses L**1**, L**2**, L**3**, L**4**, L**5**, and L**6** may be reduced, and a flare defect due to the light traveling on the paths other than the paths passing through all the first, second, third, fourth, fifth, and sixth lenses L**1**, L**2**, L**3**, L**4**, L**5**, and L**6** may be reduced. In addition, the deterioration of the MTF may be reduced or prevented.

[0098] According to one or more embodiments, the housing and the lens assembly of the camera module may be modified in various ways. In the following description, aspects that are the same as or similar to those described above may be omitted.

[0099] FIG. **7** is a cross-sectional view illustrating a camera module **100** according to one or more embodiments.

[0100] Referring to FIG. **7**, the camera module **100** may include first, second, third, fourth, fifth, and sixth lenses L**1**, L**2**, L**3**, L**4**, L**5**, and L**6**, and at least one of the first, second, third, fourth, fifth, and sixth lenses L**1**, L**2**, L**3**, L**4**, L**5**, and L**6** may have a different shape from those of the first to sixth lenses L**1** to L**6** of the above-described embodiments. In one or more embodiments, the first lens L**1** and the third lens L**3** may be provided integrally with each other without being separated from each other. In the case where the first lens L**1** is provided integrally with the third lens L**3**, there is no need to manufacture two lenses separately and assemble the two lenses, and thus processes and costs may be reduced. In this case, an object-side surface of a portion corresponding to the third lens L**3** may be formed as a reflective layer to reflect a light.

[0101] In addition, the camera module **100** may include a hood portion **113**, and the hood portion **113** may have a shape different from that of the above-described embodiments. In one or more embodiments, an inner side surface of the hood portion **113**, which defines a third hole H**3**, may have a diameter that increases from an object side to an image side. The shape of the inner side surface of the hood portion **113**, which defines the third hole H**3**, is not limited thereto. According to one or more embodiments, the shape of the third hole H**3** may be set differently depending on the design of the lenses and an optical path.

[0102] In addition, another lens may be added to the first, second, third, fourth, fifth, and sixth lenses L**1**, L**2**, L**3**, L**4**, L**5**, and L**6**. According to one or more embodiments, one or more lenses of the fourth lens LA, the fifth lens L**5**, and the sixth lens L**6** may be omitted.

[0103] According to one or more embodiments, an efficiency of the light traveling on the normal path may increase and the light traveling on the abnormal path may be blocked by adjusting the number of the lenses, the shape of the lenses, and/or the shape of the hood portion. Since the light traveling on the abnormal path is blocked, the flare defect may be prevented from occurring in the image obtained by the image sensor.

[0104] Further, the camera module may be configured to allow the TTL to decrease and to allow the total effective focal length f to increase. Accordingly, the camera module may achieve high magnification with a relatively small size.

[0105] The camera module according to one or more embodiments may be applied to various electronic devices. The electronic device, for example, may include at least one of a smartphone, a table personal computer (PC), a mobile phone, a video phone, an e-book reader, a desktop PC, a laptop PC, a netbook computer, a workstation, a server, a personal digital assistant (PDA), a portable multimedia player (PMP), an MPEG audio layer 3 (MP3) player, a mobile medical device, a camera, and a wearable device. According to one or more embodiments, the wearable device may be implemented in at least one of an accessory type (e.g., a watch, a ring, a bracelet, an anklet, a necklace, glasses, a contact lens, or a head-mounted-device (HMD)), a fabric or clothing integration type (e.g., an electronic garment), a body attachment type (e.g., a skin pad or a tattoo), and a bio-implantable type (e.g., an implantable circuit).

[0106] In one or more embodiments, the electronic device may be a home appliance. The home appliance, for example, may include at least one of a television (TV), a digital video disk (DVD) player, an audio device, a refrigerator, an air conditioner, a vacuum cleaner, an oven, a microwave, a washer, an air cleaner, a set-top box, a home automation control panel, a security control panel, a TV box (e.g., Samsung HomeSync™, Apple TV™, or Google TV™), a game console (e.g., Xbox™ or PlayStation™), an electronic dictionary, an electronic key, a camcorder, and an electronic picture frame.

[0107] In one or more embodiments, the electronic device, for example, may include at least one of various medical devices (e.g., various portable medical measurement devices (a glucometer, a heart rate meter, a blood pressure meter, a temperature gauge, etc.), a magnetic resonance angiography (MRA) device, a magnetic resonance imaging (MRI) device, a computed tomography (CT) device, a shooting device, an ultrasonic machine, etc.), a navigation device, a satellite navigation system (global navigation satellite system (GNSS)), an event data recorder (EDR), a flight data recorder (FDR), a car infotainment device, a marine electronic device (e.g., a marine navigation device, a gyro compass, or the like), avionics, a security device, a car head unit, an industrial or home robot, an automated teller machine (ATM) of a financial institution, a point of sales (POS) terminal of a shop, and Internet of things (e.g., a bulb, various sensors, an electric or gas meter, a sprinkler system, a fire alarm, a thermostat, a street light, a toaster, an exercise equipment, a hot water tank, a heater, a boiler, etc.).

[0108] In one or more embodiments, the electronic device, for example, may include at least one of a portion of furniture or a building/structure, an electronic board, an electronic signature receiving device, a projector, and various measurement devices (for example, water, electricity, gas, and electric wave measuring devices). In one or more embodiments, the electronic device may be one of the above-described devices or a combination of the devices. According to one or more embodiments, the electronic device may be flexible electronic devices. In addition, the electronic device is not limited thereto and may include new electronic devices according to the development of technologies.

[0109] Table 1 shows specifications of a lens assembly, and Table 2 shows design data of the lens assembly shown in FIG. **4**. In Table 1 below, EFL denotes an effective focal length of the lens assembly, Fno denotes the number of F, HFOV denotes a horizontal field of view, NPmax denotes a maximum value of a lens refractive index, V**1** to V**5** denote aberration values of first to fifth lenses, respectively, N**1** to N**5** denote refractive indices of the first to fifth lenses, respectively, f denotes a focal length of the lens assembly, and f**1** to f**4** respectively denote focal lengths of the first, third, fourth, and fifth lenses. In Table 2, the unit of distance is millimeters (mm).

TABLE 1

EFL	13.6
Fno	1.8
HFOV	10.5
NPmax	1.68
V1/N1	36.22
V2/N2	36.22
V3/N3	36.22
V4/N4	11.47
V5/N5	36.25
f1/f	4.0838
f2/f	0.7565
f3/f	−4.4815
f4/f	−0.7220

TABLE 2

	Lens	Diameter	Thickness	Nd	Vd	Y aperture	Focal length
S1 (L11)	First lens	8.463399684	1.0935724	1.545785042	55.99006859	4.6129575	55.540177
S2 (L13)		11.20600114	2.3250047			4.6481616	
S3 (L21)	second lens(L2) (incidence)	−12.65128087	0.5610367	1.545785042	55.99006859	4.6037863	−6.799907
S4 (L23)	second lens(L2)	−11.60954421	−0.561037	−1.545785042	55.99006859	4.6538131	
S5 (L21)	second lens(L2) (emission)	−12.65128087	−1.988182	−1	0	4.3439607	
S6 (L31)	third lens(L3) (incidence)	−35.31568294	−0.825696	−1.545785042	55.99006859	2.48	−4.354885
S7 (L33)	third lens(L3)	−8.277474385	0.8256961	1.545785042	55.99006859	1.8709682	
S8 (L31)	third lens(L3) (emission)	−35.31568294	2.2492286			1.752927	
S9 (L41)	fourth lens	4.737599817	0.5524235	1.545785042	55.99006859	2.148384	10.28855
S10 (L43)		29.06105088	0.4724473			2.3067344	
S11 (L51)	fifth lens	22.82891481	0.29809	1.676943937	19.23796972	2.337421	−60.94798
S12 (L53)		14.61942174	0.2474151			2.4349861	
S13 (L61)	sixth lens	−5.018177663	0.3	1.5367863	55.70980621	2.4612262	−9.819778
S14 (L63)		−106.7575628	0.381979			2.4288304	
S15 (131)	optic device	1E+18	0.21	1.518274025	64.16641024	3.9998354	−1E+35
S16 (133)		1E+18	0.3731196			3.9420065	

[0110] Table 3 shows aspheric coefficient values of a lens surface in the lens assembly.

TABLE 3

Surface	K	A	B	C	D	E	F	G	H	J
S1 (L11)	−10.73713	0.0014458	−0.000151	7.814E−06	4.6E−07	1.65E−08	−3.04E−10	2.299E−12	0	0
S2 (L13)	−27.68571	0.0014759	−6.49E−06	−0.000101	3.771E−05	−8.53E−06	1.332E−06	−1.49E−07	1.222E−08	−7.3E−10
S3 (L21)	0	0	0	0	0	0	0	0	0	0
S4 (L23)	0	0	0	0	0	0	0	0	0	0
S5 (L21)	0	0	0	0	0	0	0	0	0	0
S6 (L31)	29.841209	−0.002211	9.974E−05	5.807E−07	−1.01E−06	−1.41E−08	−2.89E−09	8.091E−10	1.219E−10	−1.1E−11
S7 (L33)	1.8804196	−0.000113	−2.23E−05	2.723E−05	−5.72E−06	5.987E−08	1.453E−07	−5.22E−08	7.401E−09	1.419E−10
S8 (L31)	29.841209	−0.002211	9.974E−05	5.807E−07	−1.01E−06	−1.41E−08	−2.89E−09	8.091E−10	1.219E−10	−1.1E−11
S9 (L41)	−1.59141	−0.02301	0.1101424	−0.295879	0.5632491	−0.741824	0.6822184	−0.445227	0.2086179	−0.070399
S10 (L43)	71.383781	−0.047861	0.1403329	−0.234172	0.3583407	−0.448887	0.4098942	−0.263937	0.1199592	−0.03862
S11 (L51)	80.601275	−0.231038	0.4826917	−0.624259	0.6401487	−0.587231	0.4521736	−0.265822	0.1141407	−0.035252
S12 (L53)	−32.47134	−0.232365	0.4802292	−0.551579	0.443104	−0.311937	0.2046764	−0.111632	0.0457416	−0.01351
S13 (L61)	0	0.0612729	−0.047385	−0.002637	0.0202894	−0.010997	0.0027689	−0.000364	2.355E−05	−5.68E−07
S14 (L63)	0	0.1360663	−0.211753	0.1613044	−0.073122	0.0206776	−0.003665	0.0003932	−2.31E−05	5.66E−07
S15 (131)	0	0	0	0	0	0	0	0	0	0
S16 (133)	0	0	0	0	0	0	0	0	0	0

[0111] FIG. **8** is a graph illustrating a longitudinal spherical aberration, astigmatic field curves, and a distortion aberration of the lens assembly according to one or more embodiments. The longitudinal spherical aberrations with respect to lights respectively having wavelengths of about 650.0 nanometers, about 610.0 nanometers, about 555.0 nanometers, about 510.0 nanometers, about 470.0 nanometers, and about 435.0 nanometers are shown, and a tangential field curvature (T) and a sagittal field curvature(S) are shown as the astigmatic field curves. The astigmatic field curves are shown with respect to the light having the wavelength of about 555.0 nanometers, and the distortion aberration is shown with respect to the light having the wavelength of about 555.0 nanometers.

[0112] FIG. **9** is a cross-sectional view illustrating a lens assembly according to one or more embodiments. FIG. **9** shows a lens assembly **101** utilizing lenses different sizes, different types, and with varied openings.

[0113] Table 4 shows specifications of the lens assembly, and Table 5 shows design data of the lens assembly shown in FIG. **9**. In Table 4 below, EFL denotes an effective focal length of the lens assembly, Fno denotes the number of F, HFOV denotes a horizontal field of view, NPmax denotes a maximum value of a lens refractive index, V**1** to V**5** denote aberration values of first to fifth lenses, respectively, N**1** to N**5** denote refractive indices of the first to fifth lenses, respectively, f denotes a focal length of the lens assembly, and f**1** to f**4** respectively denote focal lengths of the first, third, fourth, and fifth lenses. In Table 5, the unit of distance is millimeters (mm).

TABLE 4

EFL	14.7
Fno	1.458830985
HFOV	32.32816038
NPmax	1.68
V1/N1	36.22
V2/N2	36.22
V3/N3	36.22
V4/N4	11.47
V5/N5	36.25
f1/f	5.3787
f2/f	0.6036
f3/f	−2.8468
f4/f	−0.8409

TABLE 5

Surface	Lens	Radius	Thickness	Nd	Vd	Y Aperture	Focal Length
S1 (L11)	first lens	14.180182	1	1.545785	55.990069	5.0382807	79.067595
S2 (L13)		20.594296	2.8050284			5.0068898	
S3 (L21)	second lens(L2)	−15.52571	0.8	1.545785	55.990069	4.9817159	−8.183274

TABLE 5-continued

Surface	Lens	Radius	Thickness	Nd	Vd	Y Aperture	Focal Length
	(incidence)						
S4 (L23)	second lens(L2)	−14.04966	−0.8	1.545785	1.545785	5.0551925	
S5 (L21)	second lens(L2) (emission)	−15.52571	−2.592506			4.6415716	
S6 (L31)	third lens(L3) (incidence)	−73.51669	−0.652126	1.545785	1.545785	2.4999995	−5.425065
S7 (L33)	third lens(L3)	−10.54149	0.6521256	1.545785	55.990069	2.0906459	
S8 (L31)	third lens(L3) (emission)	−73.51669	2.9732705			2.0221627	
S9 (L41)	fourth lens	4.585729	0.8374599	1.545785	55.990069	2.35	8.8735945
S10 (L43)		80.735553	0.4345726			2.5366055	
S11 (L51)	fifth lens	22.662393	0.3	1.6769439	19.23797	2.2816581	−41.84868
S12 (L53)		12.523179	0.1863343			2.2704922	
S13 (L61)	sixth lens	−7.248627	0.4517181	1.5367863	55.709806	2.2667786	−12.36186
S14 (L63)		80.180439	0.4			2.2527326	
S15 (131)	optic device	1E+18	0.21	1.518274	64.16641	2.1934584	−1E+35
S16 (133)		1E+18	0.3804251			2.1743041	

[0114] Table 6 shows aspheric coefficient values of a lens surface in the lens assembly.

TABLE 6

Surface	K	A	B	C	D	E	F	G	H	J
S1 (L11)	−19.92734	0.0004569	−4.14E−05	1.72E−06	−7.18E−08	2.408E−09	−4.76E−11	4.071E−13	0	0
S2 (L13)	−41.86191	0.0002989	−4.67E−05	9.511E−06	−2.33E−06	4.014E−07	−4.54E−08	3.194E−09	−1.08E−10	−2.53E−12
S3 (L21)	0	0	0	0	0	0	0	0	0	0
S4 (L23)	0	0	0	0	0	0	0	0	0	0
S5 (L21)	0	0	0	0	0	0	0	0	0	0
S6 (L31)	95.040335	−0.001997	−1.99E−07	1.267E−06	5.172E−07	−1.91E−08	−4.73E−09	−2.41E−11	4.715E−11	−1.59E−12
S7 (L33)	1.8840702	−3.44E−06	−4.02E−05	1.078E−05	−9.14E−07	−5.28E−08	2.939E−08	−5.59E−10	−6.31E−10	5.909E−11
S8 (L31)	95.040335	−0.001997	−1.99E−07	1.267E−06	5.172E−07	−1.91E−08	−4.73E−09	−2.41E−11	4.715E−11	−1.59E−12
S9 (L41)	−1.410402	−0.007255	0.0295009	−0.067549	0.1093425	−0.122523	0.096071	−0.053752	0.0217552	−0.006391
S10 (L43)	97.981092	−0.042975	0.0841192	−0.096339	0.0995614	−0.09084	0.0621135	−0.029669	0.0097873	−0.002224
S11 (L51)	65.585375	−0.231609	0.400873	−0.443988	0.4070669	−0.33797	0.2269545	−0.112252	0.0397057	−0.009977
S12 (L53)	20.66437	−0.211681	0.356257	−0.347823	0.2490635	−0.16616	0.1009185	−0.048052	0.0165979	−0.004066
S13 (L61)	0	0.0723365	−0.091004	0.0544584	−0.02116	0.0060655	−0.001259	0.0001711	−1.32E−05	4.269E−07
S14 (L63)	0	0.1248292	−0.184489	0.1292973	−0.053431	0.0138077	−0.002257	0.0002265	−1.27E−05	3.058E−07
S15 (131)	0	0	0	0	0	0	0	0	0	0
S16 (133)	0	0	0	0	0	0	0	0	0	0

[0115] FIG. **10** is a graph illustrating a longitudinal spherical aberration, astigmatic field curves, and a distortion aberration of the lens assembly according to one or more embodiments. That is, FIG. **10** may correspond to FIG. **9**.

[0116] The longitudinal spherical aberrations with respect to lights respectively having wavelengths of about 650.0 nanometers, about 610.0 nanometers, about 555.0 nanometers, about 510.0 nanometers, about 470.0 nanometers, and about 435.0 nanometers are shown, and a tangential field curvature (T) and a sagittal field curvature(S) are shown as the astigmatic field curves. The astigmatic field curves are shown with respect to the light having the wavelength of about 555.0 nanometers, and the distortion aberration is shown with respect to the light having the wavelength of about 555.0 nanometers.

[0117] FIG. **11** is a cross-sectional view illustrating a lens assembly according to one or more embodiments. FIG. **11** shows a lens assembly **101** utilizing lenses different sizes, different types, and with varied openings.

[0118] Table 7 shows specifications of the lens assembly, and Table 8 shows design data of the lens assembly shown in FIG. **11**. In Table 7 below, EFL denotes an effective focal length of the lens assembly, Fno denotes the number of F, HFOV denotes a horizontal field of view, NPmax denotes a maximum value of a lens refractive index, V**1** to V**5** denote aberration values of first to fifth lenses, respectively, N**1** to N**5** denote refractive indices of the first to fifth lenses, respectively, f denotes a focal length of the lens assembly, and f**1** to f**4** respectively denote focal lengths of the first, third, fourth, and fifth lenses. In Table 8, the unit of distance is millimeters (mm).

TABLE 7

EFL	16
Fno	1.74
HFOV	9.98
NPmax	1.68
V1/N1	36.22
V2/N2	36.22
V3/N3	36.22
V4/N4	11.47
V5/N5	36.25
f1/f	5.3037
f2/f	0.5581
f3/f	−2.2725
f4/f	−0.5942

TABLE 8

Surface	Lens	Radius	Thickness	Nd	Vd	Y Aperture	Focal Length
S1 (L11)	first lens	21.862413	1.0190068	1.545785	55.990069	5.5423507	82.738495
S2 (L13)		41.682868	3.04587			5.5051386	
S3 (L21)	second lens(L2) (incidence)	−16.29898	0.8038404	1.545785	55.990069	5.4836553	−8.956237
S4 (L23)	second lens(L2)	−15.2631	−0.80384	1.545785	55.990069	5.5658964	
S5 (L21)	second lens(L2) (emission)	−16.29898	−2.796237			5.1397222	
S6 (L31)	third lens(L3) (incidence)	−31.77136	−0.801007	1.545785	55.990069	2.8491207	−5.923043
S7 (L33)	third lens(L3)	−11.01555	0.8010071	1.545785	55.990069	2.3215149	
S8 (L31)	third lens(L3) (emission)	−31.77136	3.2837372			2.2044268	
S9 (L41)	fourth lens	5.8593573	1.0146884	1.545785	55.990069	2.3958983	8.7061153
S10 (L43)		−23.59809	0.4151528			2.4847219	
S11 (L51)	fifth lens	28.78868	0.3	1.6769439	19.23797	2.5490233	−35.45058
S12 (L53)		13.032935	0.3174888			2.5883192	
S13 (L61)	sixth lens	−5.070396	0.4	1.5367863	55.709806	2.6203324	−9.268766
S14 (L63)		272.72327	0.4			2.7546017	
S15 (131)	optic device		0.21	1.518274	64.16641	2.8208063	−1E+35
S16 (133)			0.3770745			2.8413018	

[0119] Table 9 shows aspheric coefficient values of a lens surface in the lens assembly.

TABLE 9

Surface	K	A	B	C	D	E	F	G	H	J
S1 (L11)	−39.6234	0.0002043	−2.79E−05	1.918E−06	−9.8E−08	3.237E−09	−5.73E−11	4.139E−13	0	0
S2 (L13)	−97.43628	1.523E−05	−3.35E−05	7.764E−06	−1.07E−06	5.803E−08	6.42E−09	−1.59E−09	1.591E−10	−9.73E−12
S3 (L21)	0	0	0	0	0	0	0	0	0	0
S4 (L23)	0	0	0	0	0	0	0	0	0	0
S5 (L21)	0	0	0	0	0	0	0	0	0	0
S6	8.1705237	−0.001394	2.653E−06	−1.49E−06	6.278E−07	−1.37E−08	−4.78E−09	−7.17E−11	4.715E−11	−1.59E−12

TABLE 9-continued

Surface	K	A	B	C	D	E	F	G	H	J
(L31)										
S7 (L33)	1.8989392	−1.94E−06	−1.76E−05	5.337E−06	−3.18E−07	−5.89E−08	2.412E−08	−5.59E−10	−6.31E−10	5.909E−11
S8 (L31)	8.1705237	−0.001394	2.653E−06	−1.49E−06	6.278E−07	−1.37E−08	−4.78E−09	−7.17E−11	4.715E−11	−1.59E−12
S9 (L41)	−3.632352	−0.004235	0.0077238	−0.003945	−0.005753	0.0140311	−0.014935	0.0099441	−0.004492	0.0014135
S10 (L43)	−84.48934	−0.044136	0.0647699	−0.054446	0.0326293	−0.015403	0.004492	0.0003954	−0.001149	0.0005886
S11 (L51)	−12.2959	−0.208173	0.347252	−0.377784	0.3196038	−0.228901	0.1328496	−0.058657−	0.0190201	−0.004443
S12 (L53)	20.819791	−0.185664	0.3193875	−0.332073	0.2416363	−0.143298	0.0717607	−0.028863	0.0088278	−0.001984
S13 (L61)	0	0.0683763	−0.045409	−0.008091	0.0191232	−0.008679	0.0019673	−0.000246	1.629E−05	−4.45E−07
S14 (L63)	0	0.1088395	−0.1262	0.0692099	−0.022103	0.0043726	−0.000544	4.164E−05	−1.79E−06	3.327E−08
S15 (131)	0	0	0	0	0	0	0	0	0	0
S16 (133)	0	0	0	0	0	0	0	0	0	0

[0120] FIG. **12** is a graph illustrating a longitudinal spherical aberration, astigmatic field curves, and a distortion aberration of the lens assembly according to one or more embodiments. That is, FIG. **12** may correspond to FIG. **11**.

[0121] The longitudinal spherical aberrations with respect to lights respectively having wavelengths of about 650.0 nanometers, about 610.0 nanometers, about 555.0 nanometers, about 510.0 nanometers, about 470.0 nanometers, and about 435.0 nanometers are shown, and a tangential field curvature (T) and a sagittal field curvature(S) are shown as the astigmatic field curves. The astigmatic field curves are shown with respect to the light having the wavelength of about 555.0 nanometers, and the distortion aberration is shown with respect to the light having the wavelength of about 555.0 nanometers.

[0122] According to one or more embodiments, the camera module achieves high magnification while reducing a total length. In addition, the light traveling to an abnormal path in the lens assembly is blocked, and thus, defects such as flare are prevented in the camera module.

[0123] As used in connection with various embodiments of the disclosure, the term “module” may include a unit implemented in hardware, software, or firmware, and may interchangeably be used with other terms, for example, logic, logic block, part, or circuitry. A module may be a single integral component, or a minimum unit or part thereof, adapted to perform one or more functions. For example, according to an embodiment, the module may be implemented in a form of an application-specific integrated circuit (ASIC).

[0124] Various embodiments as set forth herein may be implemented as software including one or more instructions that are stored in a storage medium that is readable by a machine. For example, a processor of the machine may invoke at least one of the one or more instructions stored in the storage medium, and execute it, with or without using one or more other components under the control of the processor. This allows the machine to be operated to perform at least one function according to the at least one instruction invoked. The one or more instructions may include a code generated by a complier or a code executable by an interpreter. The machine-readable storage medium may be provided in the form of a non-transitory storage medium. Wherein, the term “non-transitory” simply means that the storage medium is a tangible device, and does not include a signal (e.g., an electromagnetic wave), but this term does not differentiate between where data is semi-permanently stored in the storage medium and where the data is temporarily stored in the storage medium.

[0125] According to an embodiment, a method according to various embodiments of the disclosure may be included and provided in a computer program product. The computer program product may be traded as a product between a seller and a buyer. The computer program product may be distributed in the form of a machine-readable storage medium (e.g., compact disc read only memory (CD-ROM)), or be distributed (e.g., downloaded or uploaded) online via an application store (e.g., PlayStore™), or between two user devices (e.g., smart phones) directly. If distributed online, at least part of the computer program product may be temporarily generated or at least temporarily stored in the machine-readable storage medium, such as memory of the manufacturer’s server, a server of the application store, or a relay server.

[0126] According to various embodiments, each component (e.g., a module or a program) of the above-described components may include a single entity or multiple entities, and some of the multiple entities may be separately disposed in different components. According to various embodiments, one or more of the above-described components may be omitted, or one or more other components may be added. Alternatively or additionally, a plurality of components (e.g., modules or programs) may be integrated into a single component. In such a case, according to 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.

[0127] At least one of the devices, units, components, modules, units, or the like represented by a block or an equivalent indication in the above embodiments including, but not limited to, FIGS. **1** and **2** may be physically implemented by analog and/or digital circuits including one or more of a logic gate, an integrated circuit, a microprocessor, a microcontroller, a memory circuit, a passive electronic component, an active electronic component, an optical component, and the like, and may also be implemented by or driven by software and/or firmware (configured to perform the functions or operations described herein).

[0128] Each of the embodiments provided in the above description is not excluded from being associated with one or more features of another example or another embodiment also provided herein or not provided herein but consistent with the disclosure.

[0129] While the disclosure has been particularly shown and described with reference to embodiments thereof, it will be understood that various changes in form and details may be made therein without departing from the spirit and scope of the following claims.

What is claimed is:

1. A camera module comprising:

a lens assembly comprising a plurality of lenses along a first optical path; and

an image sensor comprising an image surface and provided at one side of the lens assembly,

wherein the plurality of lenses comprise:

a first lens comprising a first hole through a center thereof;

a second lens adjacent to an image-side surface of the first lens, the second lens configured as a reflective type lens, and comprising a second hole through a center thereof;

a third lens adjacent to the first lens and configured as a reflective type lens;

a fourth lens adjacent to an image-side surface of the third lens; and

a fifth lens adjacent to an image-side surface of the fourth lens, and

wherein the camera module satisfies 4>f/TTL>0.5 and 0.75>D**1**/CA>0.4, where f corresponds to a total effective focal length of the lens assembly, TTL corresponds to a total track length from an object-side surface of the first lens to the image surface of the image sensor, CA corresponds to an effective diameter of the object-side surface of the first lens, and D**1** corresponds to a diameter of the first hole.

2. The camera module of claim **1**, wherein the camera module further satisfies 0.75>D**2**/CA>0.4, where D**2** corresponds a diameter of the second hole.

3. The camera module of claim **1**, further comprising a housing accommodating the lens assembly and the image sensor,

wherein the housing comprises:

a cylindrical portion configured to support the first lens, the second lens, the third lens, the fourth lens, and the fifth lens; and

a hood portion comprising a protruded portion that protrudes from an inner side surface of the cylindrical portion.

4. The camera module of claim **3**, wherein the hood portion is on a second optical path that directly connects the first lens and the fourth lens.

5. The camera module of claim **4**, wherein the hood portion penetrates the second hole.

6. The camera module of claim **4**, wherein the hood portion has a ring shape with a third hole defined through a center thereof, and

wherein an inner side surface of the hood portion defining the third hole is inclined with respect to an optical axis of the first lens, the second lens, the third lens, the fourth lens, and the fifth lens.

7. The camera module of claim **6**, wherein the inner side surface of the hood portion has a diameter that decreases as a distance from an object increases.

8. The camera module of claim **6**, wherein the inner side surface of the hood portion has a diameter that decreases as a distance from an object decreases.

9. The camera module of claim **3**, wherein the hood portion is integral with the cylindrical portion.

10. The camera module of claim **3**, wherein the camera module further satisfies TTL×0.9>HL>TTL×0.5, where HL denotes a length from an end of the protruded portion of the hood portion to the image surface of the image sensor.

11. The camera module of claim **1**, wherein an image-side surface of the second lens is a reflective surface, and

wherein an object-side surface of the third lens is a reflective surface.

12. The camera module of claim **1**, wherein the first lens has a positive refractive power,

wherein the image-side surface of the first lens has a concave shape,

wherein an image-side surface of the second lens has a convex shape,

wherein an object-side surface of the third lens has a concave shape,

wherein the fourth lens has a negative refractive power, and

wherein the image-side surface of the fourth lens has a concave shape.

13. The camera module of claim **1**, wherein at least one of the second lens and the third lens is an aspherical lens.

14. The camera module of claim **1**, wherein the first lens is integral with the third lens.

15. The camera module of claim **1**, further comprising an optic device between the fifth lens and the image sensor.

16. A lens assembly comprising a plurality of lenses along an optical path, the plurality of lenses comprising:

a first lens comprising a first hole through a center thereof;

a second lens adjacent to an image-side surface of the first lens, the second lens configured as a reflective type lens, and comprising a second hole through a center thereof;

a third lens adjacent to the first lens and configured as a reflective type lens;

a fourth lens adjacent to an image-side surface of the third lens; and

a fifth lens adjacent to an image-side surface of the fourth lens,

wherein the lens assembly satisfies 4>f/TTL>0.5, 0.75>D**1**/CA>0.4, and 0.75>D**2**/CA>0.4, where f corresponds to a total effective focal length of the lens assembly, TTL corresponds to a total track length from an object-side surface of the first lens to a focus of the lens assembly, CA corresponds to an effective diameter of the object-side surface of the first lens, D**1** corresponds to a diameter of the first hole, and D**2** corresponds to a diameter of the second hole.

17. The lens assembly of claim **16**, wherein an image-side surface of the second lens has a convex shape,

wherein the image-side surface of the second lens is a reflective surface, and

wherein an object-side surface of the third lens is a reflective surface having a concave shape.

18. The lens assembly of claim **17**, wherein at least one of the second lens and the third lens is an aspherical lens.

19. The lens assembly of claim **16**, further comprising a sixth lens having a positive refractive power and adjacent to an image-side surface of the fifth lens.

20. An electronic device comprising:

a camera module configured to obtain an image by photographing an object;

a processor configured to control the camera module to process the image; and

a memory configured to store the image,

wherein the camera module comprises:

a lens assembly comprising a plurality of lenses along an optical path; and

an image sensor comprising an image surface:

wherein the plurality of lenses comprise:

a first lens comprising a first hole through a center thereof;

a second lens adjacent to an image-side surface of the first lens, the second lens configured as a reflective type lens, and comprising a second hole through a center thereof;

a third lens adjacent to the first lens and configured as a reflective type lens;

a fourth lens adjacent to an image-side surface of the third lens; and

a fifth lens adjacent to an image-side surface of the fourth lens, and

wherein the camera module satisfies 4>f/TTL>0.5 and 0.75>D**1**/CA>0.4, where f corresponds to a total effective focal length of the lens assembly, TTL corresponds to a length from an object-side surface of the first lens to the image surface of the image sensor, CA corresponds to an effective diameter of the object-side surface of the first lens, and D**1** corresponds to a diameter of the first hole.

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