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OPTICAL IMAGING SYSTEM

Abstract

An optical imaging system includes a first lens, a second lens, a third lens, a fourth lens having a convex object-side surface, a fifth lens having a concave image-side surface, and a sixth lens, wherein the first to sixth lenses are sequentially disposed from an object side to an imaging plane. An F-number of the optical imaging system is 1.7 or less.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a continuation of U.S. patent application Ser. No. 18/418,590 filed on Jan. 22, 2024, which is a continuation of U.S. patent application Ser. No. 17/965,278 filed on Oct. 13, 2022, now U.S. Pat. No. 11,914,115, which is a continuation of U.S. patent application Ser. No. 16/739,596 filed on Jan. 10, 2020, now U.S. Pat. No. 11,500,183, which is a continuation of U.S. patent application Ser. No. 15/586,334 filed on May 4, 2017, now U.S. Pat. No. 10,782,504, which claims benefit of priority under 35 U.S.C. § 119 (a) to Korean Patent Application No. 10-2016-0179152 filed on Dec. 26, 2016 in the Korean Intellectual Property Office, the entire disclosures of which are incorporated herein by reference in their entireties for all purposes.

BACKGROUND

1. Field

[0002] The present disclosure relates to an optical imaging system including six lenses.

2. Description of Related Art

[0003] Small camera modules may be mounted in mobile communications terminals. For example, small camera modules may be mounted in devices having a thin width, such as mobile phones. Such small camera modules typically include an optical imaging system including a small number of lenses allowing for reducing the width of the device. For example, an optical imaging system of a small camera module may include four lenses or fewer.

[0004] However, an optical imaging system as described above may have a high F-number, which may make it difficult for the optical imaging system to be used in a small, high-performance camera module.

SUMMARY

[0005] This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

[0006] According to an aspect of the present disclosure, an optical imaging system includes a first lens, a second lens, a third lens, a fourth lens having a convex object-side surface, a fifth lens having a concave image-side surface, and a sixth lens. The first to sixth lenses are sequentially disposed from an object side to an imaging plane. An F-number of the optical imaging system is 1.7 or less.

[0007] The first lens of the optical imaging system may have a concave image-side surface. The second lens of the optical imaging system can have a positive refractive power. The third lens of the optical imaging system may have a refractive index of 1.65 or greater. The fourth lens of the optical imaging system may include a convex image-side surface. The fourth lens can have a refractive index of 1.65 or greater.

[0008] The fifth lens of the optical imaging system may have a negative refractive power. The fifth lens of the optical imaging system can have inflection points formed on an object-side surface and the image-side surface. The refractive index of the third lens of the optical imaging system may be 1.65 or greater. The sixth lens of the optical imaging system can have inflection points formed on

an object-side surface and an image-side surface.
[0009] In another general aspect, an optical imaging system includes a first lens, a second lens, a third lens, a fourth lens, a fifth lens, and a sixth lens, sequentially disposed from an object side to an imaging plane. The refractive indices of the third to fifth lenses are each 1.65 or greater. One or both surfaces of each of the third to fifth lenses is aspherical.
[0010] The optical imaging system may satisfy the expression $1.5<f1/f$ in which f represents an overall focal length of the optical imaging system and f1 represents a focal length of the first lens. The optical imaging system can satisfy the expression $TTL/f<1.25$ in which f represents an overall focal length of the optical imaging system and TTL represents a distance from an object-side surface of the first lens to an imaging plane. The optical imaging system may satisfy the expression $0.7<R6/f$ in which f represents an overall focal length of the optical imaging system and R6 represents a radius of curvature of an object-side surface of the third lens.
[0011] The optical imaging system may satisfy the expression $V3+V4<45$ in which V3 represents an Abbe number of the third lens and V4 represents an Abbe number of the fourth lens. The optical imaging system can satisfy the expression $V3+V5<45$ in which V3 represents an Abbe number of the third lens and V5 represents an Abbe number of the fifth lens.
[0012] In another general aspect, an optical imaging system includes a first lens having a positive refractive power, a second lens having a positive refractive power, a third lens having a negative refractive power, a fourth lens having a positive refractive power, a fifth lens having a negative refractive power, and a sixth lens having a negative refractive power. The first to sixth lenses are sequentially disposed from an object side to an imaging plane.
[0013] The optical imaging system may satisfy the expression $BFL/f>0.15$ in which BFL represents a distance from an image-side surface of the sixth lens to the imaging plane and f represents a focal length of the optical imaging system. The optical second, third, and fourth lenses of the imaging system can each have convex object-side surfaces. The first, fifth, and sixth lens of the optical imaging system may each have a concave image-side surface.

Description

BRIEF DESCRIPTION OF DRAWINGS
[0014] The above and other aspects, features, and advantages of the present disclosure will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:
[0015] FIG. **1** is a view illustrating an optical imaging system according to a first embodiment in the present disclosure;
[0016] FIG. **2** is a set of graphs having curves representing aberration characteristics of the optical imaging system illustrated in FIG. **1**;
[0017] FIG. **3** is a view illustrating an optical imaging system according to a second embodiment in the present disclosure;
[0018] FIG. **4** is a set of graphs having curves representing aberration characteristics of the optical imaging system illustrated in FIG. **3**;
[0019] FIG. **5** is a view illustrating an optical imaging system according to a third embodiment in the present disclosure;
[0020] FIG. **6** is a set of graphs having curves representing aberration characteristics of the optical imaging system illustrated in FIG. **5**;
[0021] FIG. **7** is a view illustrating an optical imaging system according to a fourth embodiment in the present disclosure; and
[0022] FIG. **8** is a set of graphs having curves representing aberration characteristics of the optical imaging system illustrated in FIG. **7**.

DETAILED DESCRIPTION

[0023] Hereinafter, embodiments of the present disclosure will be described in detail with reference to the accompanying drawings. An aspect of the present disclosure may provide an optical imaging system capable of being used in a high-performance, but sufficiently small, camera module.

[0024] Throughout the specification, it will be understood that when an element, such as a layer, region or wafer (substrate), is referred to as being “on,” “connected to,” or “coupled to” another element, it can be directly “on,” “connected to,” or “coupled to” the other element or other elements intervening therebetween may be present. In contrast, when an element is referred to as being “directly on,” “directly connected to,” or “directly coupled to” another element, there may be no elements or layers intervening therebetween. As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items.

[0025] Although terms such as “first,” “second,” and “third” may be used herein to describe various components, regions, or sections, these components, regions, or sections are not to be limited by these terms. Rather, these terms are only used to distinguish one component, region, or section from another component, region, or section. Thus, a first component, region, or section referred to in examples described herein may also be referred to as a second component, region, or section without departing from the teachings of the examples.

[0026] The articles “a,” “an,” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. The terms “comprises,” “includes,” and “has” specify the presence of stated features, numbers, operations, members, elements, and/or combinations thereof, but do not preclude the presence or addition of one or more other features, numbers, operations, members, elements, and/or combinations thereof.

[0027] Due to manufacturing techniques and/or tolerances, variations of the shapes shown in the drawings may occur. Thus, the examples described herein are not limited to the specific shapes shown in the drawings, but include changes in shape that occur during manufacturing.

[0028] The features of the examples described herein may be combined in various ways as will be apparent after an understanding of the disclosure of this application. Further, although the examples described herein have a variety of configurations, other configurations are possible as will be apparent after an understanding of the disclosure of this application.

[0029] In addition, in the present specification, a first lens refers to a lens closest to an object (or a subject), while a sixth lens refers to a lens closest to an imaging plane (or an image sensor). In addition, all of radii of curvature and thicknesses of lenses, a TTL, an IMG HT (a half of a diagonal length of the imaging plane), and focal lengths of the lenses are denoted in millimeters (mm). A person skilled in the relevant art will appreciate that other units of measurement may be used. Further, in embodiments, all radii of curvature, thicknesses, OALs (optical axis distances from the first surface of the first lens to the image sensor), a distance on the optical axis between the stop and the image sensor (SLs), image heights (IMGHs) (image heights), and back focus lengths (BFLs) of the lenses, an overall focal length of an optical system, and a focal length of each lens are indicated in millimeters (mm). Likewise, thicknesses of lenses, gaps between the lenses, OALs, TLs, SLs are distances measured based on an optical axis of the lenses.

[0030] Further, in a description of shapes of the lenses, when one surface of a lens is described as being convex, an optical axis portion of a corresponding surface is convex, and when one surface of a lens is described as being concave, an optical axis portion of a corresponding surface is concave. Therefore, even in the case that it is described that one surface of a lens is convex, an edge portion of the lens may be concave. Likewise, even in the case that it is described that one surface of a lens is concave, an edge portion of the lens may be convex. In other words, a paraxial region of a lens may be convex, while the remaining portion of the lens outside the paraxial region is either convex, concave, or flat. Further, a paraxial region of a lens may be concave, while the remaining portion of the lens outside the paraxial region is either convex, concave, or flat. In addition, in an embodiment, thicknesses and radii of curvatures of lenses are measured in relation to optical axes of the corresponding lenses.

[0031] In accordance with illustrative examples, the embodiments described of the optical system include six lenses with a refractive power. However, the number of lenses in the optical system may vary in other embodiments, for example, between two to six lenses, while achieving one or more results and benefits described below. Also, although each lens is described with a particular refractive power, a different refractive power for at least one of the lenses may be used to achieve the intended result.

[0032] An optical imaging system may include six lenses sequentially disposed from an object side toward the imaging plane. For example, the optical imaging system may include a first lens, a second lens, a third lens, a fourth lens, a fifth lens, and a sixth lens, which are sequentially disposed.

[0033] The first lens may have a refractive power. For example, the first lens has a positive refractive power. One surface of the first lens may be concave. In an embodiment, an image-side surface of the first lens is concave.

[0034] The first lens may have an aspherical surface. For example, both surfaces of the first lens are aspherical. The first lens may be formed of a material having high light transmissivity and excellent workability. In an example, the first lens is formed of plastic. However, a material of the first lens is not limited to plastic. In another example, the first lens may be formed of glass.

[0035] The first lens has a refractive index. For example, the refractive index of the first lens is less than 1.6. The first lens has an Abbe number. In an embodiment, the Abbe number of the first lens is 50 or greater.

[0036] The second lens may have a refractive power. For example, the second lens has a positive refractive power. One surface of the second lens may be convex. In an embodiment, an object-side surface of the second lens is convex.

[0037] The second lens may have an aspherical surface. For example, both surfaces of the second lens are aspherical. The second lens may be formed of a material having high light transmissivity and excellent workability. In an example, the second lens is formed of plastic. However, a material of the second lens is not limited to plastic. In another example, the second lens may also be formed of glass.

[0038] The second lens may have a refractive index that is substantially the same as or similar to that of the first lens. For example, the refractive index of the second lens is less than 1.6. The second lens may have an Abbe number. In an embodiment, the Abbe number of the second lens is 50 or greater.

[0039] The third lens may have a refractive power. For example, the third lens may have a negative refractive power. One surface of the third lens may be convex. In an embodiment, an object-side surface of the third lens is convex.

[0040] The third lens may have an aspherical surface. For example, both surfaces of the third lens are aspherical. The third lens may be formed of a material having high light transmissivity and excellent workability. In an example, the third lens is formed of plastic. However, a material of the third lens is not limited to plastic. In another example, the third lens may be formed of glass.

[0041] The third lens may have a refractive index greater than that of the first lens. For example, the refractive index of the third lens is 1.65 or greater. The third lens may have an Abbe number less than that of the first lens. In an embodiment, the Abbe number of the third lens is 21 or less.

[0042] The fourth lens may have a refractive power. For example, the fourth lens may have a positive refractive power. One surface of the fourth lens may be convex. In an embodiment, an object-side surface of the fourth lens is convex.

[0043] The fourth lens may have an aspherical surface. For example, both surfaces of the fourth lens are aspherical. The fourth lens may be formed of a material having high light transmissivity and excellent workability. In an example, the fourth lens is formed of plastic. However, a material of the fourth lens is not limited to plastic. In another example, the fourth lens may be formed of

glass.
[0044] The fourth lens may have a refractive index greater than that of the first lens. For example, the refractive index of the fourth lens is 1.65 or greater. The fourth lens may have an Abbe number less than that of the first lens. In an embodiment, the Abbe number of the fourth lens is 22 or less.
[0045] The fifth lens may have a refractive power. For example, the fifth lens has a negative refractive power. One surface of the fifth lens may be concave. In an embodiment, an image-side surface of the fifth lens is concave.
[0046] The fifth lens may have an aspherical surface. For example, both surfaces of the fifth lens are aspherical. The fifth lens may have inflection points. In an embodiment, one or more inflection points are formed on an object-side surface and the image-side surface of the fifth lens.
[0047] The fifth lens may be formed of a material having high light transmissivity and excellent workability. In an example, the fifth lens is formed of plastic. However, a material of the fifth lens is not limited to plastic. In another example, the fifth lens may be formed of glass.
[0048] The fifth lens may have a refractive index greater than that of the first lens. For example, the refractive index of the fifth lens is 1.65 or greater. The fifth lens may have an Abbe number less than that of the first lens. In an embodiment, the Abbe number of the fifth lens is 22 or less.
[0049] The sixth lens may have a refractive power. For example, the sixth lens has a negative refractive power. One surface of the sixth lens may be concave. In an embodiment, an image-side surface of the sixth lens is concave. The sixth lens may have inflection points. As examples, one or more inflection points are formed on both surfaces of the sixth lens. The sixth lens may have an aspherical surface. For example, both surfaces of the sixth lens are aspherical. The sixth lens may be formed of a material having high light transmissivity and excellent workability. As an example, the sixth lens is formed of plastic. However, a material of the sixth lens is not limited to plastic. In another example, the sixth lens may be formed of glass.
[0050] The sixth lens may have a refractive index that is substantially similar to that of the first lens. For example, the refractive index of the sixth lens is less than 1.6. The sixth lens may have an Abbe number greater than that of the fifth lens. In an embodiment, the Abbe number of the sixth lens is 50 or greater.
[0051] The first to sixth lenses may have an aspherical shape, as described above. For example, one or both surfaces of all of the first to sixth lenses are aspherical. Here, an aspherical surface of each lens may be represented by the following Equation 1:
[00001]

$$Z = \frac{cr^2}{1+\sqrt{1-(1+k)c^2r^2}} + Ar^4 + Br^6 + Cr^8 + Dr^{10} + Er^{12} + Fr^{14} + Gr^{16} + Hr^{18} + Jr^{20} . \quad \text{[Equation1]}$$

[0052] Here, c represents an inverse of a radius of curvature of the lens, k represents a conic constant, r represents a distance from a certain point on an aspherical surface of the lens to an optical axis, A to J represent aspherical constants, and Z (or SAG) represents a distance between the certain point on the aspherical surface of the lens at the distance r and a tangential plane meeting the apex of the aspherical surface of the lens.
[0053] The optical imaging system may further include a stop. The stop may be disposed between the second and third lenses. The optical imaging system may further include a filter. The filter may partially filter wavelengths of light from incident light incident through the first to sixth lenses. For example, the filter filters infrared wavelengths of the incident light.
[0054] The optical imaging system may further include an image sensor. The image sensor may provide the imaging plane on which light refracted by the lenses may be imaged. For example, a surface of the image sensor forms the imaging plane. The image sensor may be configured to implement a high level of resolution.
[0055] The optical imaging system may satisfy the following Conditional Expressions:
[00002] $1.5 < f1/f$ [ConditionalExpression1] $0.5 < f2/f < 1.5$ [ConditionalExpression2]

$$-1.5 < f3 / f < 0.5 \quad \text{[ConditionalExpression3]} \quad -10 < V1 - V2 < 10 \quad \text{[ConditionalExpression4]}$$
$$-10 < V3 - V4 < 10 \quad \text{[ConditionalExpression5]} \quad -10 < V3 - V5 < 10 \quad \text{[ConditionalExpression6]}$$
$$\mathrm{TTL} / f < 1.25 \quad \text{[ConditionalExpression7]} \quad 4.8 < \mathrm{Nd3} + \mathrm{Nd4} + \mathrm{Nd5} \quad \text{[ConditionalExpression8]}$$
$$1. < f1 / f2 < 3. \quad \text{[ConditionalExpression9]} \quad -3. < f2 / f3 < -0.5 \quad \text{[ConditionalExpression10]}$$
$$0.15 < \mathrm{BFL} / f \quad \text{[ConditionalExpression11]} \quad D2 / f < 0.08 \quad \text{[ConditionalExpression12]}$$
$$0.3 < R1 / f \quad \text{[ConditionalExpression13]} \quad 0.7 < R6 / f \quad \text{[ConditionalExpression14]}$$
$$V3 + V4 < 45 \quad \text{[ConditionalExpression15]} \quad V3 + V5 < 45 \quad \text{[ConditionalExpression16]}$$
$$F\text{ - number} \leq 1.7 . \quad \text{[ConditionalExpression17]}$$

[0056] Here, f represents an overall focal length of the optical imaging system, f1 represents a focal length of the first lens, f2 represents a focal length of the second lens, and f3 represents a focal length of the third lens. In Conditional Expression 4-6, 15, and 16, V1 represents an Abbe number of the first lens, V2 represents an Abbe number of the second lens, V3 represents an Abbe number of the third lens, V4 represents an Abbe number of the fourth lens, V5 represents an Abbe number of the fifth lens, and V6 represents an Abbe number of the sixth lens. In Conditional Expressions 7, 8 and 11, TTL represents a distance from an object-side surface of the first lens to the imaging plane, Nd3 represents a refractive index of the third lens, Nd4 represents a refractive index of the fourth lens, Nd5 represents a refractive index of the fifth lens, and BFL represents a distance from the image-side surface of the sixth lens to the imaging plane. In Conditional Expressions 12-14, D2 represents a distance from the image-side surface of the first lens to the object-side surface of the second lens, R1 represents a radius of curvature of the image-side surface of the first lens, and R6 represents a radius of curvature of the object-side surface of the third lens.

[0057] Conditional Expression 1 is a parametric ratio for implementing a bright optical system. For example, in cases in which f1/f is outside of a lower limit of Conditional Expression 1, it may not be easy to implement an optical imaging system having a low F-number.

[0058] Conditional Expression 2 is a parametric ratio for accomplishing an aberration correction effect through the second lens. For example, in cases in which f2/f is outside of upper and lower limits of Conditional Expression 2, a refractive power of the second lens may be excessively great or small, which in turn may make it difficult to correct aberration through the second lens.

[0059] Conditional Expression 3 is a parametric ratio for accomplishing an aberration correction effect through the third lens. For example, in cases in which f3/f is outside of upper and limits of Conditional Expression 3, a refractive power of the third lens may be excessively great or small, which in turn may make it difficult to correct aberration through the third lens.

[0060] Conditional Expression 4 uses parameters for accomplishing a chromatic aberration correction effect through the first lens and the second lens. For example, in cases in which V1 minus V2 satisfies a numerical range of Conditional Expression 4, a combination of the first lens and the second lens may be advantageous in correcting chromatic aberrations, which can enable implementation of an optical imaging system having a low F-number and a small TTL.

[0061] Conditional Expression 5 uses parameters for accomplishing a chromatic aberration correction effect through the third lens and the fourth lens. For example, in cases in which V3 minus V4 satisfies a numerical range of Conditional Expression 5, a combination of the third lens and the fourth lens may be advantageous in correcting chromatic aberrations, which can enable implementation of an optical imaging system having a low F-number and a small TTL.

[0062] Conditional Expression 6 uses parameters for accomplishing a chromatic aberration correction effect through the third lens and the fifth lens. For example, in cases in which V3 minus V5 satisfies a numerical range of Conditional Expression 6, a combination of the third lens and the fifth lens may be advantageous in correcting chromatic aberrations, which can enable implementation of an optical imaging system having a low F-number and a small TTL.

[0063] Conditional Expression 7 is a parametric ratio for realizing a miniaturized optical imaging system. For example, in cases in which TTL/f is outside of an upper limit of Conditional Expression 7, a total length (TTL) of the optical imaging system may be excessively long as compared to an overall focal length of the optical imaging system, such that it may be difficult to mount the optical imaging system in a small terminal.

[0064] Conditional Expression 8 is for realizing a miniaturized optical imaging system having a low F-number. For example, in cases in which the sum of Nd3, Nd4, and Nd5 is outside of a lower limit of Conditional Expression 8, it may be difficult to implement a small optical imaging system having a low F-number and a small TTL.

[0065] Conditional Expression 9 is a parametric ratio for maintaining good aberration characteristics through the first lens and the second lens. For example, in cases in which f1/f2 does not satisfy a numerical range of Conditional Expression 9, aberration characteristics may deteriorate from a combination of the first lens and the second lens due to a refractive power of any one lens being excessively greater than that of other lenses.

[0066] Conditional Expression 10 is a parametric ratio for maintaining good aberration characteristics through the second lens and the third lens. For example, in cases in which f2/f3 does not satisfy a numerical range of Conditional Expression 10, aberration characteristics may deteriorate from a combination of the second lens and the third lens due to a refractive power of any one lens being excessively greater than that of other lenses.

[0067] Conditional Expression 11 is a parametric ratio for realizing a miniaturized optical imaging system. For example, in cases in which BFL/f is outside of a numerical range of Conditional Expression 11, it may be difficult to miniaturize the optical imaging system.

[0068] Conditional Expression 12 is a parametric ratio for maintaining good longitudinal chromatic aberration characteristics through the first lens and the second lens. For example, in cases in which D2/f does not satisfy a numerical range of Conditional Expression 12, the first lens and the second lens may be disposed excessively distant from, or close to, each other. In these instances, longitudinal chromatic aberration characteristics may deteriorate.

[0069] Conditional Expression 13 is a parametric ratio for the first lens to enhance performance of the optical imaging system. For example, in cases in which R1/f is outside of a lower limit of Conditional Expression 13, the first lens may have strong refractive power. In these instances, the refractive power is advantageous in miniaturization of the optical imaging system, but may lead to difficulties in manufacturing the first lens. Conditional Expression 14 is a parametric ratio for the third lens to enhance performance of the optical imaging system.

[0070] Next, optical imaging systems according to several embodiments will be described. First, an optical imaging system according to a first embodiment will be described with reference to FIG. **1**. The optical imaging system **100** according to the first embodiment may include a plurality of lenses having refractive power. For example, optical imaging system **100** may include a first lens **110**, a second lens **120**, a third lens **130**, a fourth lens **140**, a fifth lens **150**, and a sixth lens **160**.

[0071] The first lens **110** has a positive refractive power. An object-side surface of lens **110** is convex and an image-side surface of lens **110** is concave. The second lens **120** has a positive refractive power and both surfaces of lens **120** are convex. The third lens **130** has a negative refractive power. An object-side surface of lens **130** is convex and an image-side surface of lens **130** is concave. The fourth lens **140** has a positive refractive power and both surfaces of lens **140** are convex.

[0072] The fifth lens **150** has a negative refractive power. An object-side surface of lens **150** is convex and an image-side surface of lens **150** is concave. In addition, inflection points may be formed on the object-side surface or the image-side surface of fifth lens **150**. For example, the object-side surface of fifth lens **150** is convex in a paraxial region and is concave in the vicinity of the paraxial region. Similarly in another example, the image-side surface of fifth lens **150** is concave in the paraxial region, and is convex in the vicinity of the paraxial region. The sixth lens **160** has a negative refractive power. An object-side surface of lens **160** is convex, while an image-side surface of lens **160** is concave. In addition, inflection points may be formed on both surfaces of sixth lens **160**. For example, the object-side surface of the sixth lens **160** is convex in the paraxial region and is concave in the vicinity of the paraxial region. Similarly in another example, the image-side surface of sixth lens **160** is concave in the paraxial region and is convex in the vicinity of the paraxial region.

[0073] First lens **110** and second lens **120** may have significantly low refractive indices. For example, the refractive index of first lens **110** and the refractive index of second lens **120** are 1.55 or less. The third to fifth lenses **130** to **150** may have substantially high refractive indices. In embodiments, the refractive indices of the third to fifth lenses **130** to **150** are 1.65 or greater. Sixth lens **160** may have the lowest refractive index in optical imaging system **100**. As an example, the refractive index of the sixth lens **160** is 1.54 or less.

[0074] First lens **110** and second lens **120** may have the highest Abbe numbers in optical imaging system **100**. For example, the Abbe numbers of first lens **110** and second lens **120** are 55 or greater. Third lens **130** may have the lowest Abbe number in optical imaging system **100**. In an embodiment, the Abbe number of third lens **130** is 21 or less. Fourth lens **140** and fifth lens **150** may have significantly low Abbe numbers. As examples, the Abbe numbers of fourth lens **140** and fifth lens **150** are 23 or less. Sixth lens **160** may have an Abbe number substantially similar to that of first lens **110**. For example, the Abbe number of sixth lens **160** is 50 or greater.

[0075] Optical imaging system **100** may include a stop ST. For example, stop ST is disposed between second lens **120** and third lens **130**. Stop ST disposed as described above controls an amount of light incident on an imaging plane **180**.

[0076] Optical imaging system **100** may include a filter **170**. For example, filter **170** is disposed between sixth lens **160** and imaging plane **180**. Filter **170** disposed as described above filters infrared light incident to imaging plane **180**.

[0077] Optical imaging system **100** may include an image sensor. The image sensor provides imaging plane **180** on which light refracted through the lenses is imaged. In addition, the image sensor may convert an optical signal imaged on imaging plane **180** into an electrical signal.

[0078] Optical imaging system **100** configured as described above may have a low F-number. As an example, the F-number of the optical imaging system according to the present embodiment is 1.70.

[0079] The optical imaging system according to the embodiment of FIG. **1** has aberration characteristics as illustrated by the graphs in FIG. **2**. Table 1 lists characteristics of lenses of the optical imaging system according to the present embodiment, and Table 2 lists aspherical characteristics of the optical imaging system according to the present embodiment.

TABLE-US-00001 TABLE 1 First Embodiment F No. = 1.70 f = 4.104 TTL = 4.857 Surface Radius of Thickness/ Refractive Abbe Focal No. Element Curvature Distance Index Number Length S1 First Lens 2.0468 0.4822 1.546 56.09 7.254 S2 3.8988 0.1327 S3 Second Lens 2.8693 0.4832 1.546 56.09 3.828 S4 −7.1455 0.0200 S5 Stop Infinity 0.0000 S6 Third Lens 6.9588 0.2400 1.667 20.35 −4.206 S7 1.9597 0.4218 S8 Fourth Lens 54.3803 0.3916 1.656 21.53 29.041 S9 −28.8561 0.5084 S10 Fifth Lens 2.9623 0.4104 1.656 21.53 −33.838 S11 2.4683 0.2537 S12 Sixth Lens 1.5026 0.5186 1.537 55.71 −44.182 S13 1.2429 0.1935 S14 Filter Infinity 0.1100 1.516 55.15 S15 Infinity 0.6900 S16 Imaging Plane Infinity 0.0000

TABLE-US-00002 TABLE 2 Surface No. S1 S2 S3 S4 S6 S7 S8 Radius of 2.0468 3.8988 −2.7995 −45.5055 40.8195 −6.1666 −0.1111 Curvature K −1.2476 −6.3785 −0.0377 0.1428 0.0247 −0.0131 0.1393 A −0.0156 −0.0707 0.0117 −0.5712 −0.1991 0.2171 −0.4820 B −0.0128 −0.0278 −0.2086 1.0037 0.2053 −0.4716 1.2813 C −0.0042 −0.0018 0.5820 −1.0820 0.2177 0.7414 −2.0969 D −0.0138 0.1135 −0.6447 0.7074 −0.7201 −0.7002 2.0217 E 0.0186 −0.1283 0.3507 −0.2498 0.6556 0.3623 −1.0491 F −0.0049 0.0674 −0.0800 0.0334 −0.2139 −0.0689 0.0000 G −0.0003 −0.0150 0.0000 0.0000 0.0000 0.0000 0.0000 H 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 J 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 Surface No. S9 S10 S11 S12 S13

Radius of −47.3382 −1.0282 −39.9318 1.5026 1.2429 Curvature K −0.1244 −0.0833 0.0005 −11.1029 −5.0263 A 0.1085 0.0899 0.0362 −0.2536 −0.1745 B −0.2389 −0.1668 −0.0796 0.1111 0.0998 C 0.4542 0.1461 0.0560 −0.0131 −0.0463 D −0.5226 −0.0793 −0.0216 −0.0077 0.0148 E 0.3594 0.0262 0.0048 0.0039 −0.0029 F −0.1333 0.0000 0.0000 −0.0008 0.0003 G 0.0000 0.0000 0.0000 0.0000 0.0000 H 0.0000 0.0000 0.0000 0.0000 0.0000 J 0.0000 0.0000 0.0000 0.0000 0.0000

[0080] An optical imaging system according to a second embodiment will be described with reference to FIG. **3**. The optical imaging system **200** according to the second embodiment may include a plurality of lenses having refractive power. For example, the optical imaging system **200** includes a first lens **210**, a second lens **220**, a third lens **230**, a fourth lens **240**, a fifth lens **250**, and a sixth lens **260**.

[0081] The first lens **210** has a positive refractive power. An object-side surface of lens **210** is convex and an image-side surface of lens **210** is concave. The second lens **220** has a positive refractive power and both surfaces of lens **220** are convex. The third lens **230** has a negative refractive power. An object-side surface of lens **230** is convex and an image-side surface of lens **230** is concave. The fourth lens **240** has a positive refractive power and both surfaces of lens **240** are convex.

[0082] The fifth lens **250** has a negative refractive power. An object-side surface of lens **250** is convex and an image-side surface of lens **250** is concave. In addition, inflection points may be formed on the object-side surface and the image-side surface of fifth lens **250**. In an embodiment, the object-side surface of fifth lens **250** is convex in a paraxial region and is concave in the vicinity of the paraxial region. Similarly in an embodiment, the image-side surface of fifth lens **250** is concave in the paraxial region and is convex in the vicinity of the paraxial region. The sixth lens **260** has a negative refractive power. An object-side surface of lens **260** is convex and an image-side surface of lens **260** is concave. In addition, inflection points may be formed on both surfaces of sixth lens **260**. For example, the object-side surface of sixth lens **260** is convex in the paraxial region, and is concave in the vicinity of the paraxial region. Similarly in other embodiments, the image-side surface of sixth lens **260** is concave in the paraxial region and is convex in the vicinity of the paraxial region.

[0083] First lens **210** and second lens **220** may have significantly low refractive indices. For example, the refractive index of first lens **210** and the refractive index of second lens **220** are each 1.55 or less. The third to fifth lenses **230** to **250** may have substantially high refractive indices. In embodiments, the refractive indices of the third to fifth lenses **230** to **250** are 1.65 or greater. Sixth lens **260** may have the lowest refractive index in optical imaging system **200**. For example, the refractive index of sixth lens **260** is 1.54 or less.

[0084] First lens **210** and second lens **220** may have the highest Abbe numbers in optical imaging system **200**. For example, the Abbe numbers of first lens **210** and second lens **220** are 55 or greater. Third lens **230** may have the lowest Abbe number in optical imaging system **200**. As an example, the Abbe number of third lens **230** is 21 or less. Fourth lens **240** and fifth lens **250** may have significantly low Abbe numbers. As other examples, the Abbe numbers of fourth lens **240** and fifth lens **250** are 23 or less. Sixth lens **260** may have an Abbe number substantially similar to that of first lens **210**. In an embodiment, the Abbe number of sixth lens **260** is 50 or greater.

[0085] Optical imaging system **200** may include a stop ST. For example, stop ST is disposed between second lens **220** and third lens **230**. Stop ST disposed as described above controls an amount of light incident to an imaging plane **280**.

[0086] Optical imaging system **200** may include a filter **270**. As an example, filter **270** is disposed between sixth lens **260** and imaging plane **280**. Filter **270** disposed as described above filters infrared light incident to imaging plane **280**.

[0087] Optical imaging system **200** may include an image sensor. The image sensor may provide imaging plane **280** on which light refracted through the lenses is imaged. In addition, the image

sensor may convert an optical signal imaged on imaging plane **280** into an electrical signal.
[0088] Optical imaging system **200** configured as described above may have a low F-number. In an embodiment, the F-number of the optical imaging system according to the present embodiment is 1.70.
[0089] The optical imaging system according to the embodiment of FIG. **3** has aberration characteristics as illustrated by the graphs in FIG. **4**. Table 3 lists characteristics of lenses of the optical imaging system according to the present embodiment, and Table 4 lists aspherical characteristics of the optical imaging system according to the present embodiment.
TABLE-US-00003 TABLE 3 Second Embodiment F No. = 1.70 f = 4.105 TTL = 4.839 Surface Radius of Thickness/ Refractive Abbe Focal No. Element Curvature Distance Index Number Length S1 First Lens 2.1000 0.4788 1.546 56.09 7.059 S2 4.2611 0.1300 S3 Second Lens 2.8645 0.4901 1.546 56.09 3.998 S4 −8.4983 0.0200 S5 Stop Infinity 0.0000 S6 Third Lens 6.9565 0.2400 1.667 20.35 −4.379 S7 2.0164 0.4211 S8 Fourth Lens 30.6105 0.3537 1.656 21.53 27.182 S9 −41.6544 0.5348 S10 Fifth Lens 2.8698 0.4009 1.656 21.53 −31.390 S11 2.3776 0.2472 S12 Sixth Lens 1.4178 0.4600 1.537 55.71 −36.706 S13 1.1728 0.1852 S14 Filter Infinity 0.2100 1.517 64.20 S15 Infinity 0.6625 S16 Imaging Plane Infinity 0.0000
TABLE-US-00004 TABLE 4 Surface No. S1 S2 S3 S4 S6 S7 S8 Radius of 2.1000 4.2611 2.8645 −8.4983 6.9565 2.0164 30.6105 Curvature K −1.3011 −4.7492 −1.7396 −38.3364 41.0805 −6.0911 A −0.0173 −0.0723 −0.0334 0.1185 0.0071 −0.0130 −0.1198 B −0.0167 −0.0271 0.0033 −0.5033 −0.1742 0.2081 0.1199 C 0.0058 0.0256 −0.1500 0.9416 0.2786 −0.4316 −0.3363 D −0.0279 0.0596 0.4787 −1.1062 −0.0527 0.7010 0.8207 E 0.0334 −0.0785 −0.5648 0.8040 −0.3581 −0.7157 −1.2719 F −0.0127 0.0437 0.3223 −0.3233 0.4301 0.4118 1.1688 G 0.0013 −0.0105 −0.0773 0.0517 −0.1598 −0.0904 −0.5730 H 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 J 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 Surface No. S9 S10 S11 S12 S13 Radius of −41.6544 2.8698 2.3776 1.4178 1.1728 Curvature K 0.0000 −0.8479 −40.9006 −11.3538 −5.3896 A −0.1319 −0.0855 0.0087 −0.2846 −0.1936 B 0.1046 0.0854 0.0207 0.1265 0.1161 C −0.1933 −0.1581 −0.0665 −0.0145 −0.0569 D 0.3530 0.1372 0.0490 −0.0094 0.0195 E −0.4009 −0.0741 −0.0193 0.0048 −0.0043 F 0.2793 0.0244 0.0043 −0.0010 0.0006 G −0.1058 0.0000 0.0000 0.0000 0.0000 H 0.0000 0.0000 0.0000 0.0000 0.0000 J 0.0000 0.0000 0.0000 0.0000 0.0000
[0090] An optical imaging system according to a third embodiment will be described with reference to FIG. **5**. The optical imaging system **300** according to the third embodiment may include a plurality of lenses having refractive power. For example, the optical imaging system **300** may include a first lens **310**, a second lens **320**, a third lens **330**, a fourth lens **340**, a fifth lens **350**, and a sixth lens **360**.
[0091] The first lens **310** has a positive refractive power. An object-side surface of lens **310** is convex and an image-side surface of lens **310** is concave. The second lens **320** has a positive refractive power and both surfaces of lens **320** are convex. The third lens **330** has a negative refractive power. An object-side surface of lens **330** is convex and an image-side surface of lens **330** is concave. The fourth lens **340** has a positive refractive power and both surfaces of lens **340** are convex.
[0092] The fifth lens **350** has a positive refractive power. An object-side surface of lens **350** is convex and an image-side surface of lens **350** is concave. In addition, inflection points may be formed on the object-side surface and the image-side surface of fifth lens **350**. For example, the object-side surface of fifth lens **350** is convex in a paraxial region and is concave in the vicinity of the paraxial region. Similarly in an embodiment, the image-side surface of fifth lens **350** is concave in the paraxial region and is convex in the vicinity of the paraxial region. The sixth lens **360** has a negative refractive power. An object-side surface of lens **360** is convex and an image-side surface of lens **360** is concave. In addition, inflection points may be formed on both surfaces of the sixth lens **360**. As an example, the object-side surface of sixth lens **360** is convex in the paraxial region and is concave in the vicinity of the paraxial region. Similarly in an example, the image-side

surface of sixth lens **360** is concave in the paraxial region and is convex in the vicinity of the paraxial region.

[0093] First lens **310** and second lens **320** may have significantly low refractive indices. For example, the refractive index of first lens **310** and the refractive index of second lens **320** are each 1.55 or less. The third to fifth lenses **330** to **350** may have substantially high refractive indices. In embodiments, the refractive indices of the third to fifth lenses **330** to **350** are each 1.65 or greater. Sixth lens **360** may have the lowest refractive index in optical imaging system **300**. For example, the refractive index of sixth lens **360** is 1.54 or less.

[0094] First lens **310** and second lens **320** may have the highest Abbe numbers in optical imaging system **300**. As examples, the Abbe numbers of first lens **310** and second lens **320** are 55 or greater. Third lens **330** may have the lowest Abbe number in optical imaging system **300**. As another example, the Abbe number of third lens **330** is 21 or less. Fourth lens **340** and fifth lens **350** may have significantly low Abbe numbers. In embodiments, the Abbe numbers of fourth lens **340** and fifth lens **350** are 23 or less. Sixth lens **360** may have an Abbe number substantially similar to that of first lens **310**. For example, the Abbe number of sixth lens **360** is 50 or greater.

[0095] Optical imaging system **300** may include a stop ST. As an example, stop ST may be disposed between second lens **320** and third lens **330**. Stop ST disposed as described above controls an amount of light incident to an imaging plane **380**.

[0096] Optical imaging system **300** includes a filter **370**. For example, filter **370** is disposed between sixth lens **360** and imaging plane **380**. Filter **370** disposed as described above filters infrared light incident to imaging plane **380**.

[0097] Optical imaging system **300** may include an image sensor. The image sensor may provide imaging plane **380** on which light refracted through the lenses is imaged. In addition, the image sensor may convert an optical signal imaged on imaging plane **380** into an electrical signal.

[0098] Optical imaging system **300** configured as described above has a low F-number. For example, the F-number of the optical imaging system according to the present embodiment is 1.60.

[0099] The optical imaging system according to the embodiment of FIG. **5** has aberration characteristics as illustrated by the graphs in FIG. **6**. Table 5 lists characteristics of lenses of the optical imaging system according to the present embodiment, and Table 6 lists aspherical characteristics of the optical imaging system according to the present embodiment.

TABLE-US-00005 TABLE 5 Third Embodiment F No. = 1.60 f = 4.326 TTL = 5.204 Surface Radius of Thickness/ Refractive Abbe Focal No. Element Curvature Distance Index Number Length S1 First Lens 2.2000 0.5155 1.546 56.09 6.917 S2 4.8584 0.2492 S3 Second Lens 4.3005 0.5673 1.546 56.09 4.610 S4 −5.7401 0.0200 S5 Stop Infinity 0.0000 S6 Third Lens 7.2235 0.2400 1.667 20.35 −5.382 S7 2.3524 0.5225 S8 Fourth Lens 83.6139 0.4270 1.656 21.53 56.553 S9 −65.5350 0.3574 S10 Fifth Lens 3.0298 0.4967 1.656 21.53 45.623 S11 3.1564 0.3141 S12 Sixth Lens 1.5205 0.3902 1.537 55.71 −10.302 S13 1.0851 0.2201 S14 Filter Infinity 0.2100 1.518 64.20 S15 Infinity 0.6535 S16 Imaging Plane Infinity 0.0000

TABLE-US-00006 TABLE 6 Surface No. S1 S2 S3 S4 S6 S7 S8 Radius of 2.2000 4.8584 4.3005 −5.7401 7.2235 2.3524 83.6139 Curvature K −1.0659 −1.9795 −2.2607 −44.3319 31.2128 −8.7788 0.0000 A −0.0118 −0.0359 −0.0172 0.0687 0.0053 0.0042 −0.0299 B −0.0010 −0.0120 −0.0016 −0.3343 −0.2074 0.0373 −0.0554 C −0.0182 0.0184 −0.0044 0.5323 0.3002 −0.0956 0.2747 D 0.0223 −0.0180 0.0151 −0.5127 −0.2182 0.1311 −0.5854 E −0.0187 0.0168 −0.0059 0.3004 0.0773 −0.0793 0.7101 F 0.0093 −0.0064 −0.0002 −0.0984 −0.0036 0.0174 −0.5035 G −0.0018 0.0008 −0.0001 0.0136 −0.0037 0.0018 0.1942 H 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 J 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 Surface No. S9 S10 S11 S12 S13 Radius of −65.5350 3.0298 3.1564 1.5205 1.0851 Curvature K 0.0000 −5.9984 −49.3158 −10.2282 −5.1695 A −0.0796 −0.0478 0.0237 −0.3072 −0.2020 B −0.0012 0.0026 −0.0337 0.1406 0.1169 C 0.0898 −0.0300 0.0029 −0.0297 −0.0527 D −0.1307 0.0280 0.0045 0.0012 0.0169 E 0.1029 −0.0164 −0.0027 0.0009 −0.0035 F −0.0444 0.0060 0.0008 −0.0002 0.0004 G 0.0097 0.0000

0.0000 0.0000 0.0000 H 0.0000 0.0000 0.0000 0.0000 0.0000 J 0.0000 0.0000 0.0000 0.0000 0.0000

[0100] An optical imaging system according to a fourth embodiment will be described with reference to FIG. **7**. The optical imaging system **400** according to the fourth embodiment may include a plurality of lenses having refractive power. For example, the optical imaging system **400** may include a first lens **410**, a second lens **420**, a third lens **430**, a fourth lens **440**, a fifth lens **450**, and a sixth lens **460**.

[0101] The first lens **410** has a positive refractive power. An object-side surface of lens **410** is convex and an image-side surface of lens **410** is concave. The second lens **420** has a positive refractive power and both surfaces of lens **420** are convex. The third lens **430** has a negative refractive power. An object-side surface of lens **430** is convex and an image-side surface of lens **430** is concave. The fourth lens **440** has a positive refractive power and both surfaces of lens **440** are convex.

[0102] The fifth lens **450** has a negative refractive power. An object-side surface of lens **450** is convex and an image-side surface of lens **450** is concave. In addition, inflection points may be formed on the object-side surface and the image-side surface of fifth lens **450**. In an embodiment, the object-side surface of fifth lens **450** is convex in a paraxial region and is concave in the vicinity of the paraxial region. Similarly in an embodiment, the image-side surface of fifth lens **450** is concave in the paraxial region and is convex in the vicinity of the paraxial region. The sixth lens **460** has a negative refractive power. An object-side surface of lens **460** is convex and an image-side surface of lens **460** is concave. In addition, inflection points may be formed on both surfaces of sixth lens **460**. For example, the object-side surface of sixth lens **460** is convex in the paraxial region and is concave in the vicinity of the paraxial region. Similarly in an example, the image-side surface of sixth lens **460** is concave in the paraxial region and is convex in the vicinity of the paraxial region.

[0103] First lens **410** and second lens **420** may have significantly low refractive indices. In examples, the refractive index of first lens **410** and the refractive index of second lens **420** are each 1.55 or less. The third to fifth lenses **430** to **450** may have substantially high refractive indices. As examples, the refractive indices of the third to fifth lenses **430** to **450** are each 1.65 or greater. Sixth lens **460** may have the lowest refractive index in optical imaging system **400**. In an embodiment, the refractive index of sixth lens **460** is 1.54 or less.

[0104] First lens **410** and second lens **420** may have the highest Abbe numbers in optical imaging system **400**. For example, the Abbe numbers of first lens **410** and second lens **420** are 55 or greater. Third lens **430** may have the lowest Abbe number in optical imaging system **400**. In an embodiment, the Abbe number of third lens **430** is 21 or less. Fourth lens **440** and fifth lens **450** may have significantly low Abbe numbers. For example, the Abbe numbers of fourth lens **440** and fifth lens **450** are each 23 or less. Sixth lens **460** may have an Abbe number substantially similar to that of first lens **410**. In an embodiment, the Abbe number of sixth lens **460** is 50 or greater.

[0105] Optical imaging system **400** may include a stop ST. For example, stop ST is disposed between second lens **420** and third lens **430**. Stop ST disposed as described above controls an amount of light incident to an imaging plane **480**.

[0106] Optical imaging system **400** may include a filter **470**. For example, filter **470** is disposed between sixth lens **460** and imaging plane **480**. Filter **470** disposed as described above filters infrared light incident to imaging plane **480**.

[0107] Optical imaging system **400** may include an image sensor. The image sensor may provide imaging plane **480** on which light refracted through the lenses is imaged. In addition, the image sensor may convert an optical signal imaged on imaging plane **480** into an electrical signal.

[0108] Optical imaging system **400** configured as described above may have a low F-number. As an example, the F-number of the optical imaging system according to the present embodiment is 1.60.

[0109] The optical imaging system according to the embodiment of FIG. **7** has aberration characteristics as illustrated by the graphs in FIG. **8**. Table 7 lists characteristics of lenses of the optical imaging system according to the present embodiment, and Table 8 lists aspherical characteristics of the optical imaging system according to the present embodiment.

TABLE-US-00007 TABLE 7 Fourth Embodiment F No. = 1.60 f = 4.327 TTL = 5.208 Surface Radius of Thickness/ Refractive Abbe Focal No. Element Curvature Distance Index Number Length S1 First Lens 2.1776 0.4976 1.546 56.09 8.845 S2 3.6572 0.1441 S3 Second Lens 2.6894 0.5643 1.546 56.09 3.871 S4 −8.9939 0.0200 S5 Stop Infinity 0.0000 S6 Third Lens 7.7066 0.2463 1.667 20.35 −4.586 S7 2.1483 0.4559 S8 Fourth Lens 86.8308 0.4187 1.656 21.53 30.120 S9 −25.2482 0.5272 S10 Fifth Lens 3.1020 0.4327 1.656 21.53 −84.879 S11 2.7755 0.2824 S12 Sixth Lens 1.8002 0.5643 1.537 55.71 −25.018 S13 1.4134 0.2076 S14 Filter Infinity 0.2100 1.518 64.20 S15 Infinity 0.6270 S16 Imaging Plane Infinity 0.0000

TABLE-US-00008 TABLE 8 Surface No. S1 S2 S3 S4 S6 S7 S8 Radius of 2.1776 3.6572 2.6894 −8.9939 7.7066 2.1483 86.8308 Curvature K −1.2579 −8.5811 −3.0148 −58.3944 39.2664 −6.0744 0.0000 A −0.0119 −0.0554 −0.0321 0.1224 0.0344 −0.0073 −0.0823 B −0.0104 −0.0231 0.0047 −0.4526 −0.2313 0.1456 0.0804 C 0.0014 0.0051 −0.0981 0.7558 0.3920 −0.3226 −0.2318 D −0.0124 0.0450 0.2312 −0.7591 −0.3069 0.5256 0.5233 E 0.0120 −0.0424 −0.2016 0.4557 0.0692 −0.5049 −0.7259 F −0.0034 0.0175 0.0836 −0.1497 0.0438 0.2571 0.5911 G 0.0002 −0.0030 −0.0144 0.0203 −0.0212 −0.0504 −0.2573 H 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 J 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 Surface No. S9 S10 S11 S12 S13 Radius of −25.2482 −1.8525 2.7755 1.8002 1.4134 Curvature K 0.0000 −0.0677 −36.6800 −11.2324 −4.6357 A −0.0956 0.0671 0.0000 −0.1977 −0.1366 B 0.0655 −0.1043 0.0259 0.0752 0.0659 C −0.1157 0.0779 −0.0498 −0.0100 −0.0254 D 0.1862 −0.0358 0.0307 −0.0025 0.0065 E −0.1811 0.0099 −0.0104 0.0013 −0.0010 F 0.1056 0.0000 0.0020 −0.0002 0.0001 G −0.0331 0.0000 0.0000 0.0000 0.0000 H 0.0000 0.0000 0.0000 0.0000 0.0000 J 0.0000 0.0000 0.9000 0.0000 0.0000

[0110] Table 9 lists values of Conditional Expressions of the optical imaging systems according to the first to fourth embodiments. As can be seen in Table 9, the optical imaging systems according to the first to fourth embodiments satisfy all numerical ranges of the Conditional Expressions suggested in the detailed description of the present disclosure.

TABLE-US-00009 TABLE 9 Conditional First Second Third Fourth Expression Embodiment Embodiment Embodiment Embodiment Embodiment f1/f 1.7674 1.7195 1.5988 2.0438 f2/f 0.9326 0.9739 1.0656 0.8945 f3/f −1.0248 −1.0667 −1.2439 −1.0597 V1-V2 0 0 0 0 V3-V4 −1.1718 −1.1718 −1.1718 −1.1718 V3-V5 −1.1718 −1.1718 −1.1718 −1.1718 TTL/f 1.1834 1.1788 1.2027 1.2035 Nd3 + Nd4 + Nd5 4.9784 4.9784 4.9784 4.9784 f1/f2 1.8951 1.7655 1.5003 2.2849 f2/f3 −0.9101 −0.9130 −0.8567 −0.8441 BFL/f 0.2423 0.2589 0.2528 0.2437 D2/f 0.0323 0.0317 0.0576 0.0333 R1/f 0.4987 0.5115 0.5085 0.5032 R6/f 1.6955 1.6945 1.6696 1.7809 V3 + V4 41.88 41.88 41.88 41.88 V3 + V5 41.88 41.88 41.88 41.88 F-number 1.70 1.70 1.60 1.60

[0111] As set forth above, according to the embodiments in the present disclosure, an optical imaging system appropriate for a small camera module having high performance may be implemented. While embodiments have been shown and described above, it will be apparent after an understanding of this application that modifications and variations could be made without departing from the scope of the present application as defined by the appended claims.

Claims

1. An optical imaging system comprising: a first lens comprising a refractive power; a second lens comprising a refractive power; a third lens comprising a refractive power; a fourth lens comprising a refractive power; a fifth lens comprising a convex object-side surface in a paraxial region; and a sixth lens comprising a refractive power, wherein the first to sixth lenses are sequentially disposed from an object side to an imaging plane, wherein the optical imaging system has a total number of six lenses with refractive power, wherein a thickness of the fifth lens along an optical axis is greater than a thickness of the fourth lens along an optical axis, wherein a thickness of the sixth lens along an optical axis is greater than a thickness of the third lens along an optical axis, wherein an absolute value of a radius of curvature of an object-side surface of the second lens is greater that an absolute value of a radius of curvature of an object-side surface of the first lens, and wherein an absolute value of a radius of curvature of an object-side surface of the fourth lens is greater that an absolute value of a radius of curvature of an object-side surface of the third lens.

2. The optical imaging system of claim 1, wherein the first lens has a convex object-side surface in a paraxial region.

3. The optical imaging system of claim 1, wherein the second lens has a convex object-side surface in a paraxial region.

4. The optical imaging system of claim 1, wherein the third lens has a convex object-side surface in a paraxial region.

5. The optical imaging system of claim 1, wherein the fourth lens has a convex image-side surface in a paraxial region.

6. The optical imaging system of claim 1, wherein the sixth lens has a concave image-side surface in a paraxial region.

7. An optical imaging system comprising: a first lens comprising a refractive power; a second lens comprising a refractive power; a third lens comprising a convex object-side surface in a paraxial region; a fourth lens comprising a refractive power; a fifth lens comprising a refractive power; and a sixth lens comprising a concave image-side surface in a paraxial region, wherein the first to sixth lenses are sequentially disposed from an object side to an imaging plane, wherein the optical imaging system has a total number of six lenses with refractive power, wherein a thickness of the sixth lens along an optical axis is greater than a thickness of the third lens along an optical axis, wherein an absolute value of a radius of curvature of an object-side surface of the third lens is greater that an absolute value of a radius of curvature of an image-side surface of the fifth lens, and wherein $-10<V3-V5<10$, where V3 is an Abbe number of the third lens and V5 is an Abbe number of the fifth lens.

8. The optical imaging system of claim 7, wherein the first lens has a convex object-side surface in a paraxial region.

9. The optical imaging system of claim 7, wherein the second lens has a convex object-side surface in a paraxial region.

10. The optical imaging system of claim 7, wherein the third lens has a concave image-side surface in a paraxial region.

11. The optical imaging system of claim 7, wherein the fourth lens has a convex image-side surface in a paraxial region.

12. The optical imaging system of claim 7, wherein the fifth lens has a convex object-side surface in a paraxial region.