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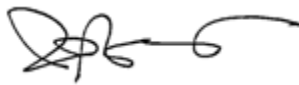
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Taiwan Application No. 102131525

I declare that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Executed on June 20, 2020



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Application Date	Sep. 2, 2013
Application No.	102131525
Applicant(s)	Ability Opto-Electronics Technology Co., Ltd.
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Oct. 14, 2013

Abstract

※ Application Number:

※ Application Date:

※ IPC Classification:

Title of the Invention: Thin wide-angle four-piece imaging lens assembly

[Chinese]

A thin wide-angle four-piece imaging lens assembly comprises a lens set and a fixed diaphragm, wherein the lens set comprises, sequentially from an object side to an image side along an optical axis, a first lens, a second lens, a third lens, and a fourth lens with the refractive power being positive, positive, negative, and positive, the surface of the first lens facing the object side and adjacent to the central optical axis is a convex surface, the surface of the second lens facing the image side and adjacent to the central optical axis is a convex surface, the surface of the third lens facing the object side and adjacent to the central optical axis is a concave surface and the surface thereof facing the image side and adjacent to the central optical axis is a convex surface, and the surface of the fourth lens facing the image side and adjacent to the central optical axis is a concave surface, and the fourth lens has at least one inflection point located between the optical axis and the aspherical end point; the fixed diaphragm is located between the object side and the second lens and satisfies $15 < \text{HFOV}/f < 50$, wherein HFOV represents one half of a maximum angle of view of the lens assembly, and f represents a focal length of the lens assembly; and a higher HFOV value and a lower f value can make the volume of the entire lens assembly denser and improve the resolving power. Therefore, the present invention has advantages of both compact and thin design and high performance.

[English]

[Representative Image]

[The designated representative image in this case] Figure (1).

[Brief explanation of component legends in this image]

1.....lens set	14fourth lens
11.....first lens	2fixed diaphragm
12.....second lens	ct1-ct4thickness
13.....third lens	

[If there are chemical formulae in this case, please disclose a chemical formula that can best illustrate the features of the invention]:

Specification of Invention Patent
(Please do not alter the format or sequence of this specification)

[Title of the Invention] Thin wide-angle four-piece imaging lens assembly

[Field of the Invention]

[0001] The present invention relates to an imaging lens assembly, and in particular to a thin wide-angle four-piece imaging lens assembly.

[Description of the Prior Art]

[0002] A conventional imaging lens assembly is an imaging lens assembly adopted in an electronic product, such as a mobile phone, a smart phone, a tablet computer, a notebook computer, a camera, and the like. With the continuous improvement of electronic products, a gradual trend appears toward compact and thin design while achieving high performance. As a result, imaging lens assemblies are developed to have thin dimensions and become more compact as a whole. On the other hand, to improve the resolving power, imaging lens assemblies need to be developed to have a wider angle.

[0003] While conventional imaging lens assemblies, such as those according to the patents TW201215941A, TW201224568A, and TW201239443A, are disclosed to be four-piece imaging lens assemblies, none of the embodiments in the patents further meet the requirements for a thin and wide-angle design.

[0004] Therefore, in order to enable an electronic device to achieve advantages of both compact and thin design and high performance, a wide-angle imaging lens assembly having thin dimensions that make the overall assembly more compact and capable of improving the resolving power is currently desired on the market.

[Summary of the Invention]

[0005] Therefore, the objective of the present invention is to provide a thin wide-angle four-piece imaging lens assembly having thin dimensions that make the overall assembly more compact and capable of improving the resolving power.

[0006] Accordingly, the thin wide-angle four-piece imaging lens assembly of the present invention comprises a lens set and a fixed diaphragm. The lens set includes a first lens, a second lens, a third lens, and a fourth lens arranged in sequence from an object side to an image side along an optical axis. The first lens has a positive refractive power adjacent to the central optical axis and has a convex surface that faces the object side, and the first lens has at least one surface that is an aspherical surface. The second lens has a positive refractive power adjacent to the central optical axis and has a convex surface that faces the image side, and the second lens has at least one surface that is an aspherical surface. The third lens has a negative refractive power adjacent to the central optical axis and has a concave surface that faces the object side and a convex surface that faces the image side, and the third lens has at least one surface that is an aspherical surface. The fourth lens has a positive refractive power adjacent to the central optical axis and has a concave surface that faces the image side, both surfaces of the fourth lens are aspherical surfaces, and at least one of the two surfaces has at least one inflection point located between the optical axis and the aspherical end point. The fixed diaphragm is located between the object side and the second lens. Here, the thin wide-angle four-piece imaging lens assembly satisfies the following condition:

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[0007] $15 < \text{HFOV}/f < 50$,

[0008] wherein HFOV represents one half of a maximum angle of view of the lens assembly and has a unit of degree, and f represents a focal length of the thin wide-angle four-piece imaging lens assembly and has a unit of millimeter.

[0009] The thin wide-angle four-piece imaging lens assembly according to the present invention, wherein the thin wide-angle four-piece imaging lens assembly satisfies the following condition:

[0010] $\text{HFOV} > 35^\circ$.

[0011] The thin wide-angle four-piece imaging lens assembly according to the present invention, wherein the thin wide-angle four-piece imaging lens assembly satisfies the following condition:

[0012] $f < 2.7 \text{ mm}$.

[0013] The thin wide-angle four-piece imaging lens assembly according to the present invention, wherein the thin wide-angle four-piece imaging lens assembly satisfies the following conditions:

[0014] $\text{Nd}_3 > 1.56$, and

[0015] $V_3 < 29$,

[0016] wherein Nd_3 is a refractive index of the third lens, and V_3 is a dispersion coefficient of the third lens.

[0017] The thin wide-angle four-piece imaging lens assembly according to the present invention, wherein the thin wide-angle four-piece imaging lens assembly satisfies the following conditions:

[0018] $\text{Nd}_2 < 1.56$, and

[0019] $V_2 > 29$,

[0020] wherein Nd_2 is a refractive index of the second lens, and V_2 is a dispersion coefficient of the second lens.

[0021] The thin wide-angle four-piece imaging lens assembly according to the present invention, wherein the thin wide-angle four-piece imaging lens assembly satisfies the following condition:

[0022] $0.8 < |f/f_3| < 2.5$,

[0023] wherein f_3 represents a focal length of the third lens and has a unit of millimeter.

[0024] The thin wide-angle four-piece imaging lens assembly according to the present invention, wherein the thin wide-angle four-piece imaging lens assembly satisfies the following conditions:

[0025] $0.3 < ct1/ct2 < 2.0$, and

[0026] $0 < ct3/ct4 < 1.0$,

[0027] wherein $ct1$ is a center thickness of the first lens, $ct2$ is a center thickness of the second lens, $ct3$ is a center thickness of the third lens, and $ct4$ is a center thickness of the fourth lens, all of which have a unit of millimeter.

[0028] The present invention achieves the effect that the thin wide-angle four-piece imaging lens assembly satisfies $15 < HFOV/f < 50$. A higher value of HFOV represents a wider angle of view of the present invention that can increase the resolving power thereof, while a lower value of f indicates that the present invention has thin dimensions that make the overall assembly more compact. Therefore, the present invention enables an electronic device to achieve advantages of both compact and thin design and high performance, thereby achieving the objective of the present invention.

[Brief Description of the Drawings]

[0029] Other features and advantages of the present invention will become apparent in the following embodiments with reference to the accompanying drawings, wherein:

FIG. 1 is a schematic diagram of an optical structure illustrating a first specific embodiment of the thin wide-angle four-piece imaging lens assembly according to the present invention;

FIG. 2 is a schematic diagram illustrating astigmatism aberration and distortion aberration of the first specific embodiment;

FIG. 3 is a schematic diagram illustrating spherical aberration of the first specific embodiment;

FIG. 4 is a schematic diagram of an optical structure illustrating a second specific embodiment of the thin wide-angle four-piece imaging lens assembly according to the present invention;

FIG. 5 is a schematic diagram illustrating astigmatism aberration and distortion aberration of the second specific embodiment;

FIG. 6 is a schematic diagram illustrating spherical aberration of the second specific embodiment;

FIG. 7 is a schematic diagram of an optical structure illustrating a third specific embodiment of the thin wide-angle four-piece imaging lens assembly according to the present invention;

FIG. 8 is a schematic diagram illustrating astigmatism aberration and distortion aberration of the third specific embodiment; and

FIG. 9 is a schematic diagram illustrating spherical aberration of the third specific embodiment.

[Detailed Description of the Specific embodiments]

[0030] Referring to FIG. 1, the thin wide-angle four-piece imaging lens assembly according to the present invention comprises a lens set 1, a fixed diaphragm 2, a filter lens 3, and an imaging surface 4.

[0031] The lens set 1 includes a first lens 11, a second lens 12, a third lens 13, and a fourth lens 14 arranged in sequence from an object side to an image side along an optical axis L. The first lens 11 has a positive refractive power adjacent to the central optical axis L and has a convex surface that faces the object side, and the first lens 11 has at least one surface that is an aspherical surface. The second lens 12 has a positive refractive power adjacent to the central optical axis L and has a convex surface that faces the image side, and the second lens 12 has at least one surface that is an aspherical surface. The third lens 13 has a negative refractive power adjacent to the central optical axis L and has a concave surface that faces the object side and a convex surface that faces the image side, and the third lens 13 has at least one surface that is an aspherical surface. The fourth lens 14 has a positive refractive power adjacent to the central optical axis L and has a concave surface that faces the image side, both surfaces of the fourth lens 14 are aspherical surfaces, and at least one of the two surfaces has at least one inflection point located between the optical axis L and the aspherical end point. The fixed diaphragm 2 is located between the object side and the second lens 12. Here, the thin wide-angle four-piece imaging lens assembly satisfies the following conditions:

- | | |
|----------------------------------|----------|
| [0032] $15 < \text{HFOV}/f < 50$ | (1), |
| [0033] $0.8 < f/f_3 < 2.5$ | (2), |
| [0034] $0.3 < ct_1/ct_2 < 2.0$ | (3), and |
| [0035] $0 < ct_3/ct_4 < 1.0$ | (4), |

[0036] in which HFOV represents one half of a maximum angle of view of the lens assembly and has a unit of degree, f represents a focal length of the thin wide-angle four-piece imaging lens assembly and has a unit of millimeter, f_3 is a focal length of the third lens 13 and has a unit of millimeter, ct_1 represents a center thickness of the first lens 11, ct_2 represents a center thickness of the second lens 12, ct_3 represents a center thickness of the third lens 13, and ct_4 represents a center thickness of the fourth lens 14, all of which have a unit of millimeter.

[0037] More preferably, the thin wide-angle four-piece imaging lens assembly satisfies the following conditions:

- | | |
|---------------------------------|----------|
| [0038] $\text{HFOV} > 35^\circ$ | (5), and |
| [0039] $f < 2.7 \text{ mm}$ | (6), |

[0040] wherein the condition (1) indicates that a higher value of HFOV represents a wider angle of view of the present invention that can increase the resolving power thereof, while a lower value of f indicates that the present invention has thin dimensions that make the overall assembly more compact. The conditions (5) and (6) further describe advantages of the wide angle of view and the thin dimensions of the present invention.

[0041] It should be noted that the thin wide-angle four-piece imaging lens assembly satisfies the following conditions:

- [0042] $Nd3 > 1.56$ (7),
 [0043] $V3 < 29$ (8),
 [0044] $Nd2 < 1.56$ (9), and
 [0045] $V2 > 29$ (10)

[0046] wherein $Nd3$ is a refractive index of the third lens 13, $V3$ is a dispersion coefficient of the third lens 13, $Nd2$ is a refractive index of the second lens 12, and $V2$ is a dispersion coefficient of the second lens 12. The conditions (7) to (10) describe that the refractive power of the third lens 13 is greater than the refractive power of the second lens 12 according to the present invention.

[0047] Moreover, the aspherical surfaces of the present invention satisfy the following condition:

$$z = \frac{ch^2}{1 + [1 - (k+1)c^2h^2]^{0.5}} + Ah^4 + Bh^6 + Ch^8 + Dh^{10} + Eh^{12} + Fh^{14} + Gh^{16} + Hh^{18} + Jh^{20} + \dots$$

[0048]
 [0049] (11),

[0050] wherein z is a position value of a position at a height of h along the optical axis L with reference to a vertex of the surface, k is the conic constant, c is a reciprocal of the radius of curvature, and $A, B, C, D, E, F, G, H, J, \dots$ are high-order aspheric coefficients. Surface profiles of the aspherical surfaces are able to correct aberrations, reduce tolerance sensitivity, and provide a wide-angle capability for the present invention.

[0051] <First Specific Embodiment>

[0052] Referring to FIG. 1, FIG. 2, and FIG. 3, parameters of the first specific embodiment are as follows: $f1=2.19$ mm, $f2=2.05$ mm, $f3=-1.16$ mm, $f4=1.52$ mm, $f=1.60$ mm, $ct1=0.284$ mm, $ct2=0.368$ mm, $ct3=0.190$ mm, $ct4=0.472$ mm, and $HFOV=44^\circ$.

[0053] The first specific embodiment satisfies the conditions (1) to (11), where $HFOV/f=27.5$, $|f/f3|=1.38$, $ct1/ct2=0.77$, $ct3/ct4=0.40$, $Nd2=1.535$, $Nd3=1.636$, $V2=56.07$, and $V3=23.89$.

[0054] FIG. 2 illustrates astigmatism aberration and distortion aberration of the first specific embodiment. FIG. 3 illustrates spherical aberration.

[0055]

Data of the lens in the first specific embodiment						
Surface		Radius of curvature (Radius)	Thickness/ Interspace (Thickness)	Refractive index (Nd)	Abbe number (Vd)	Focal length (mm)
Fixed diaphragm		∞	-0.03			
First lens 11	First surface	1.361	0.284	1.535	56.07	2.19
	Second surface	-8.119	0.194			
Second lens 12	Third surface	-2.042	0.368	1.535	56.07	2.05
	Fourth surface	-0.760	0.159			
Third lens 13	Fifth surface	-0.289	0.190	1.636	23.89	-1.16
	Sixth surface	-0.596	0.038			
Fourth lens 14	Seventh surface	0.488	0.472	1.535	56.07	1.52
	Eighth surface	0.805	0.25			
Filter lens	Ninth surface	∞	0.21	1.517	64.17	
	Tenth surface	∞	0.332			

[0056] Aspherical parameters of the first specific embodiment are as follows:

[0057]

	First surface	Second surface	Third surface	Fourth surface	Fifth surface	Sixth surface	Seventh surface	Eighth surface
k	0	0	6.191788	-3.784132	-3.838175	-1.077896	-7.06691	-2.241616
A	-0.2065838	-0.7720604	-1.4905075	-1.1446487	-4.9202522	-0.5217609	0.10412867	-0.3678477
B	-3.3390093	1.4937038	13.548352	-13.499105	18.914991	0.96784978	-1.6835431	0.10715581
C	45.617387	-48.87327	-222.85883	142.67618	-20.771041	12.065814	4.2811759	0.31062561
D	-568.5172	417.56966	1762.543	-811.19607	12.125511	-36.497597	-6.3438122	-0.5323217
E	3836.6411	-1866.3668	-7503.2608	2964.6502	-142.85927	22.957229	5.6351203	0.37789525
F	-14300.609	3693.0414	17228.893	-6161.6996	243.02698	33.940443	-2.7711759	-0.1331061
G	22470.012	-1072.5651	-16174.808	5342.2346	30.761799	-33.635537	0.58039414	0.018683511

[0058] <Second Specific Embodiment>

[0059] Referring to FIG. 3, FIG. 4, and FIG. 5, parameters of the second specific embodiment are as follows: $f_1=2.39$ mm, $f_2=2.08$ mm, $f_3=-1.45$ mm, $f_4=1.85$ mm, $f=1.60$ mm, $ct_1=0.276$ mm, $ct_2=0.392$ mm, $ct_3=0.204$ mm, $ct_4=0.450$ mm, and $HFOV=44^\circ$.

[0060] The second specific embodiment satisfies the conditions (1) to (11), where $HFOV/f=27.5$, $|f/f_3|=1.10$, $ct_1/ct_2=0.70$, $ct_3/ct_4=0.45$, $Nd_2=1.535$, $Nd_3=1.636$, $V_2=56.07$, and $V_3=23.89$.

[0061] FIG. 4 illustrates astigmatism aberration and distortion aberration of the second specific embodiment. FIG. 5 illustrates spherical aberration.

[0062]

Data of the lens in the second specific embodiment						
Surface		Radius of curvature (Radius)	Thickness/ Interspace (Thickness)	Refractive index (Nd)	Abbe number (Vd)	Focal length (mm)
First lens 11	First surface	1.172	0.276	1.535	56.07	2.39
	Second surface	12.524	0.002			
Fixed diaphragm		∞	0.193			
Second lens 12	Third surface	-2.352	0.392	1.535	56.07	2.08
	Fourth surface	-0.800	0.165			
Third lens 13	Fifth surface	-0.295	0.204	1.636	23.89	-1.45
	Sixth surface	-0.550	0.022			
Fourth lens 14	Seventh surface	0.526	0.450	1.535	56.07	1.85
	Eighth surface	0.786	0.25			
Filter lens	Nineth surface	∞	0.21	1.517	64.17	
	Tenth surface	∞	0.352			

[0063] Aspherical parameters of the second specific embodiment are as follows:

[0064]

	First surface	Second surface	Third surface	Fourth surface	Fifth surface	Sixth surface	Seventh surface	Eighth surface
k	-27.67006	0	0	-0.1133277	-3.670904	-1.681659	-7.045281	-3.872049
A	1.9885098	-0.37701082	-0.96274237	-0.00025411	-3.9824733	-0.37652375	0.000309204	-0.15744128
B	-16.754161	-0.49422655	2.5787486	-13.638266	9.3522783	-3.5402459	-1.3786241	-0.21216838
C	121.87784	-25.697915	-75.20593	119.14826	-14.277191	22.786238	3.9107049	0.6311134
D	-697.96568	372.82808	563.02784	-775.83633	58.628841	-34.875393	-6.1155891	-0.74118053
E	2523.3236	-3090.4143	-2537.022	3121.5568	13.198369	-6.5038799	5.4923776	0.45196807
F	-5159.4588	12641.659	4107.643	-6765.6192	-631.1631	60.790568	-2.5266688	-0.14266076
G	4272.9124	-20091.048	1821.596	6044.1686	956.17439	-37.919506	0.51902791	0.01825282

[0065] <Third Specific Embodiment>

[0066] Referring to FIG. 6, FIG. 7, and FIG. 8, parameters of the third specific embodiment are as follows: $f_1=2.55$ mm, $f_2=0.86$ mm, $f_3=-0.61$ mm, $f_4=0.98$ mm, $f=1.13$ mm, $ct_1=0.239$ mm, $ct_2=0.266$ mm, $ct_3=0.187$ mm, $ct_4=0.429$ mm, $HFOV=44^\circ$.

[0067] The third specific embodiment satisfies the conditions (1) to (11), where $HFOV/f=39.0$, $|f/f_3|=1.85$, $ct_1/ct_2=0.90$, $ct_3/ct_4=0.44$, $Nd_2=1.535$, $Nd_3=1.636$, $V_2=56.07$, and $V_3=23.89$.

[0068] FIG. 7 illustrates astigmatism aberration and distortion aberration of the third specific embodiment. FIG. 8 illustrates spherical aberration.

[0069]

Data of the lens in the third specific embodiment						
Surface		Radius of curvature (Radius)	Thickness/ Interspace (Thickness)	Refractive index (Nd)	Abbe number (Vd)	Focal length (mm)
Fixed diaphragm		∞	-0.001			
First lens 11	First surface	1.903	0.239	1.535	56.07	2.55
	Second surface	-4.616	0.062			
Second lens 12	Third surface	3.029	0.266	1.535	56.07	0.86
	Fourth surface	-0.528	0.095			
Third lens 13	Fifth surface	-0.184	0.187	1.636	23.89	-0.61
	Sixth surface	-0.483	0.092			
Fourth lens 14	Seventh surface	0.430	0.429	1.535	56.07	0.98
	Eighth surface	1.549	0.125			
Filter lens	Ninth surface	∞	0.210	1.517	64.17	
	Tenth surface	∞	0.325			

[0070] Aspherical parameters of the third specific embodiment are as follows:

[0071]

	First surface	Second surface	Third surface	Fourth surface	Fifth surface	Sixth surface	Seventh surface	Eighth surface
k	8.58328	-2824.922	42.97767	0.7395685	-1.926854	-0.3569793	-5.810289	1.443596
A	-1.2031657	-9.8439198	-7.1130345	0.63242517	-4.0319876	-0.15762397	-0.05755995	-0.20237191
B	12.223278	116.10956	4.0234552	-132.3459	-130.00916	3.7724173	-1.4813813	0.7721049
C	-1918.3111	-1775.4567	-507.43521	2590.488	3983.5728	116.23539	9.9370396	-8.9338663
D	6722.3948	-15124.178	-7707.7496	-20847.637	-22497.967	-218.09901	-60.63752	26.574088
E	2123163.2	652775.39	80989.53	158170.7	-103474.15	-4855.6445	190.69088	-38.350854
F	-52922573	-5158083.1	1130631.4	-1000249.5	1277642.5	24221.919	-287.85565	27.456949
G	3.7786e+008	11596365	-8089358.7	3411687.3	-3002346	-32489.178	163.69987	-8.006268

[0072] In summary, the effects achieved by the present invention are as follows:

[0073] I. The present invention is characterized in that the thin wide-angle four-piece imaging lens assembly satisfies $15 < \text{HFOV}/f < 50$. Moreover, the present invention also improves the resolving power, increases the wide angle of view, and reduces the thickness to become thinner by satisfying the conditions (2) to (11).

[0074] II. A higher value of HFOV represents a wider angle of view of the present invention that can increase the resolving power thereof.

[0075] III. A lower value of f indicates that the present invention has thin dimensions that make the overall assembly more compact.

[0076] The present invention enables an electronic device to achieve advantages of both compact and thin design and high performance, thereby achieving the objective of the present invention.

[0077] However, the description above are only preferred embodiments of the present invention, which may not be used to limit the scope of the present invention. Any simple equivalent variations and modifications made according to the content of the claims and the specification of the present invention shall fall within the scope of the present invention patent.

[Description of Legends]

[0078]

1.....lens set	2fixed diaphragm
11.....first lens	3filter lens
12.....second lens	4imaging surface
13.....third lens	Loptical axis
14.....fourth lens	ct1-ct4thickness

[Biological material registration]

Domestic registration information [remarks shall follow the order of registering agency, date, and number]

Foreign registration information [remarks shall follow the order of registering country, agency, date, and number]

[Sequence Listing] (please record on a separate page)

Claims

1. A thin wide-angle four-piece imaging lens assembly, comprising
a lens set including a first lens, a second lens, a third lens, and a fourth lens arranged in sequence from an object side to an image side along an optical axis,
wherein the first lens has a positive refractive power adjacent to the central optical axis and has a convex surface that faces the object side, and the first lens has at least one surface that is an aspherical surface,
the second lens has a positive refractive power adjacent to the central optical axis and has a convex surface that faces the image side, and the second lens has at least one surface that is an aspherical surface,
the third lens has a negative refractive power adjacent to the central optical axis and has a concave surface that faces the object side and a convex surface that faces the image side, and the third lens has at least one surface that is an aspherical surface, and
the fourth lens has a positive refractive power adjacent to the central optical axis and has a concave surface that faces the image side, both surfaces of the fourth lens are aspherical surfaces, and at least one of the two surfaces has at least one inflection point located between the optical axis and the aspherical end point; and
a fixed diaphragm located between the object side and the second lens,
wherein the thin wide-angle four-piece imaging lens assembly satisfies the following condition:
 $15 < \text{HFOV}/f < 50$,
wherein HFOV represents one half of a maximum angle of view of the lens assembly and has a unit of degree, and f represents a focal length of the thin wide-angle four-piece imaging lens assembly and has a unit of millimeter.
2. The thin wide-angle four-piece imaging lens assembly according to claim 1, wherein the thin wide-angle four-piece imaging lens assembly satisfies the following condition:
 $\text{HFOV} > 35^\circ$.
3. The thin wide-angle four-piece imaging lens assembly according to claim 1, wherein the thin wide-angle four-piece imaging lens assembly satisfies the following condition:
 $f < 2.7 \text{ mm}$.
4. The thin wide-angle four-piece imaging lens assembly according to claim 1, wherein the thin wide-angle four-piece imaging lens assembly satisfies the following conditions:
 $\text{Nd}_3 > 1.56$, and
 $V_3 < 29$,
wherein Nd_3 is a refractive index of the third lens, and V_3 is a dispersion coefficient of the third lens.
5. The thin wide-angle four-piece imaging lens assembly according to claim 4, wherein the thin wide-angle four-piece imaging lens assembly satisfies the following conditions:
 $\text{Nd}_2 < 1.56$, and
 $V_2 > 29$,

wherein Nd2 is a refractive index of the second lens, and V2 is a dispersion coefficient of the second lens.

6. The thin wide-angle four-piece imaging lens assembly according to claim 1, wherein the thin wide-angle four-piece imaging lens assembly satisfies the following condition:

$$0.8 < |f/f_3| < 2.5,$$

wherein f3 represents a focal length of the third lens and has a unit of millimeter.

7. The thin wide-angle four-piece imaging lens assembly according to claim 1, wherein the thin wide-angle four-piece imaging lens assembly satisfies the following conditions:

$$0.3 < ct_1/ct_2 < 2.0, \text{ and}$$

$$0 < ct_3/ct_4 < 1.0,$$

wherein ct1 is a center thickness of the first lens, ct2 is a center thickness of the second lens, ct3 is a center thickness of the third lens, and ct4 is a center thickness of the fourth lens, all of which have a unit of millimeter.

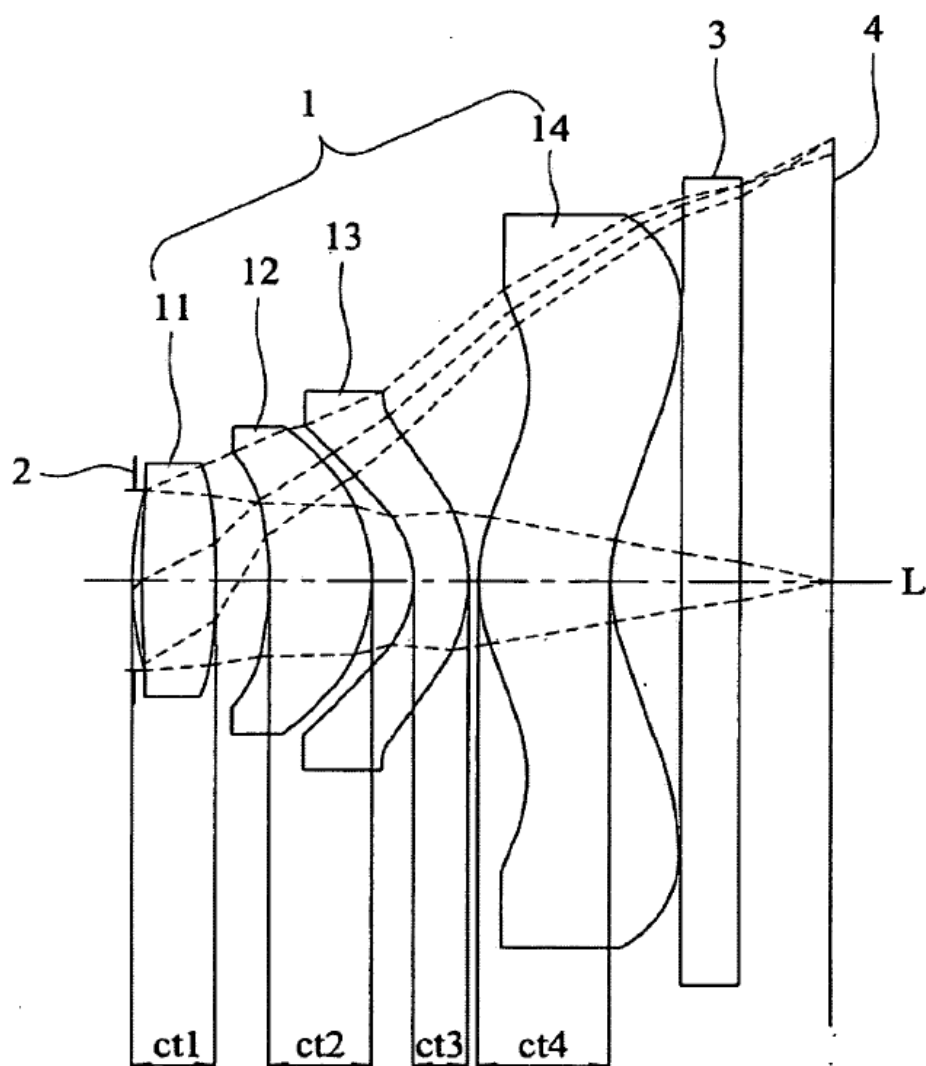


Fig. 1

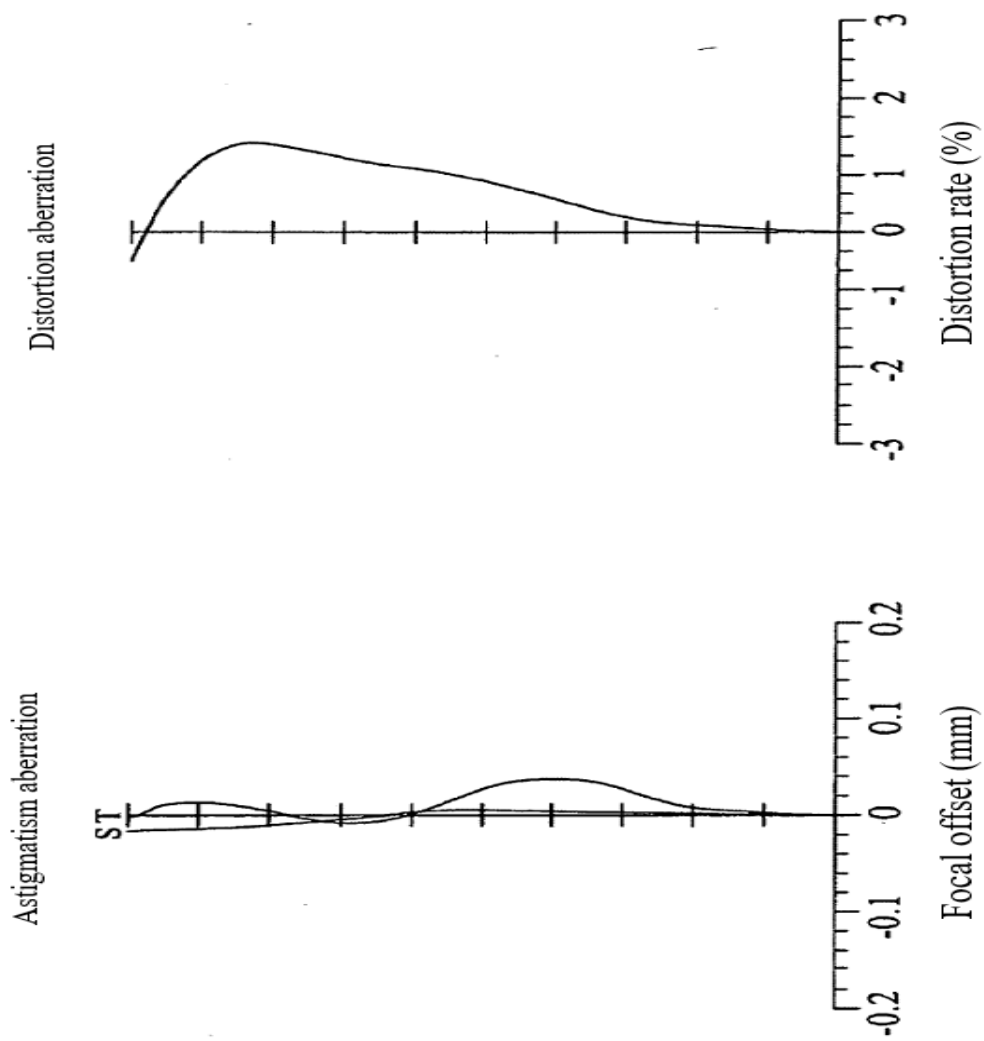


Fig. 2

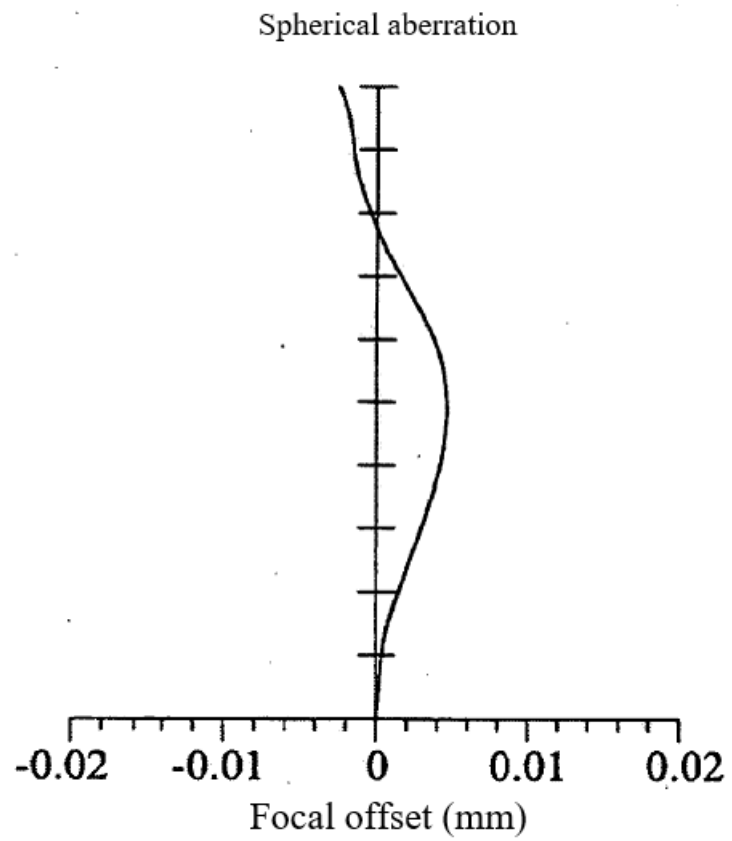


Fig. 3

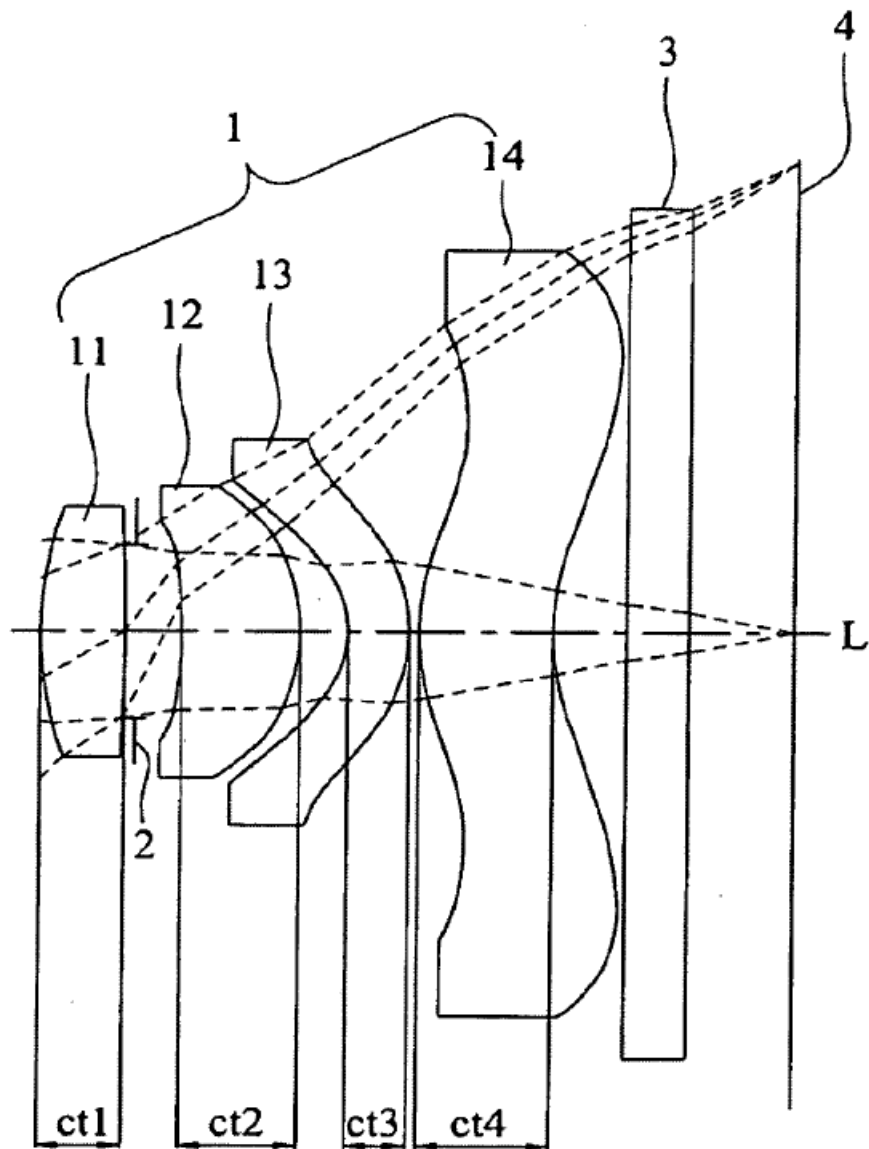


Fig. 4

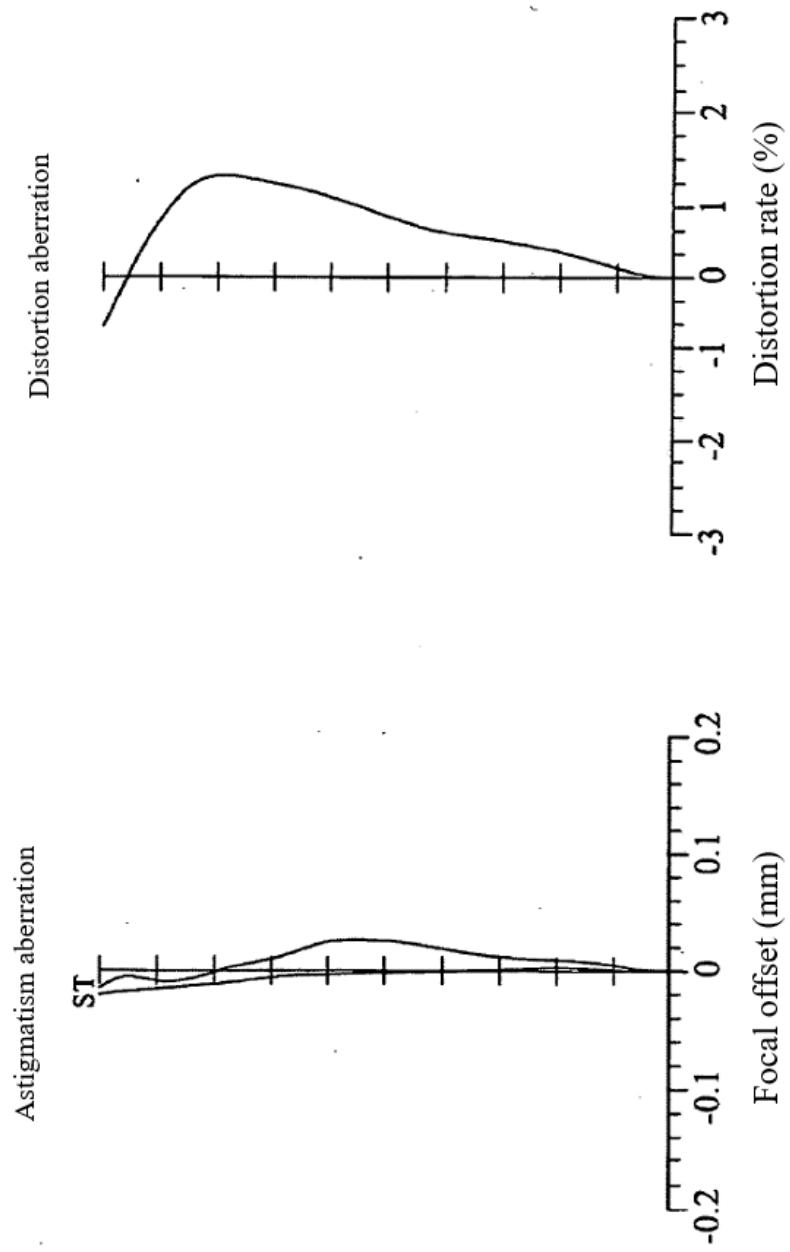


Fig. 5

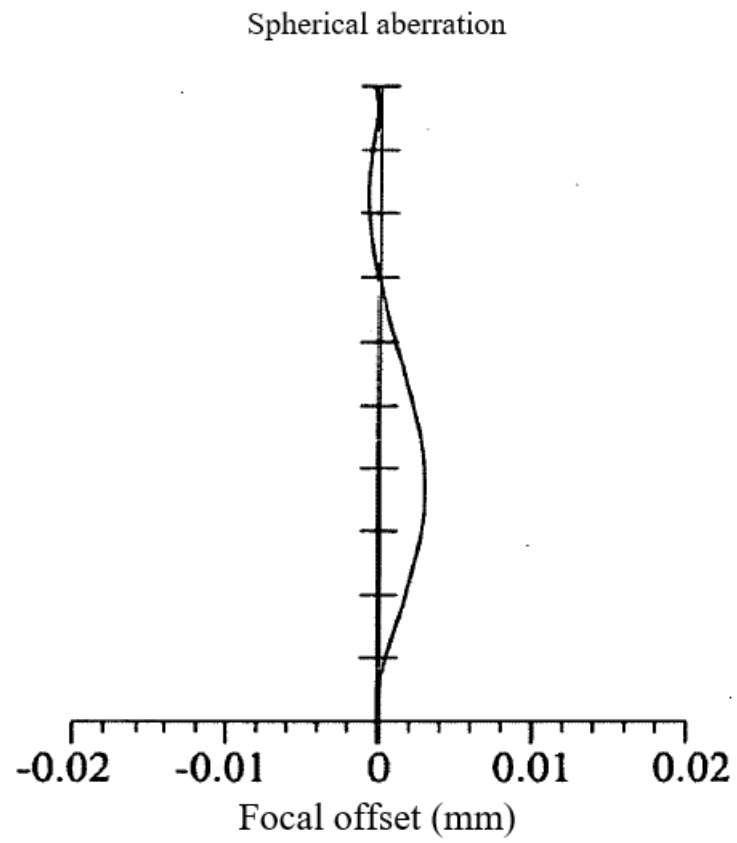


Fig. 6

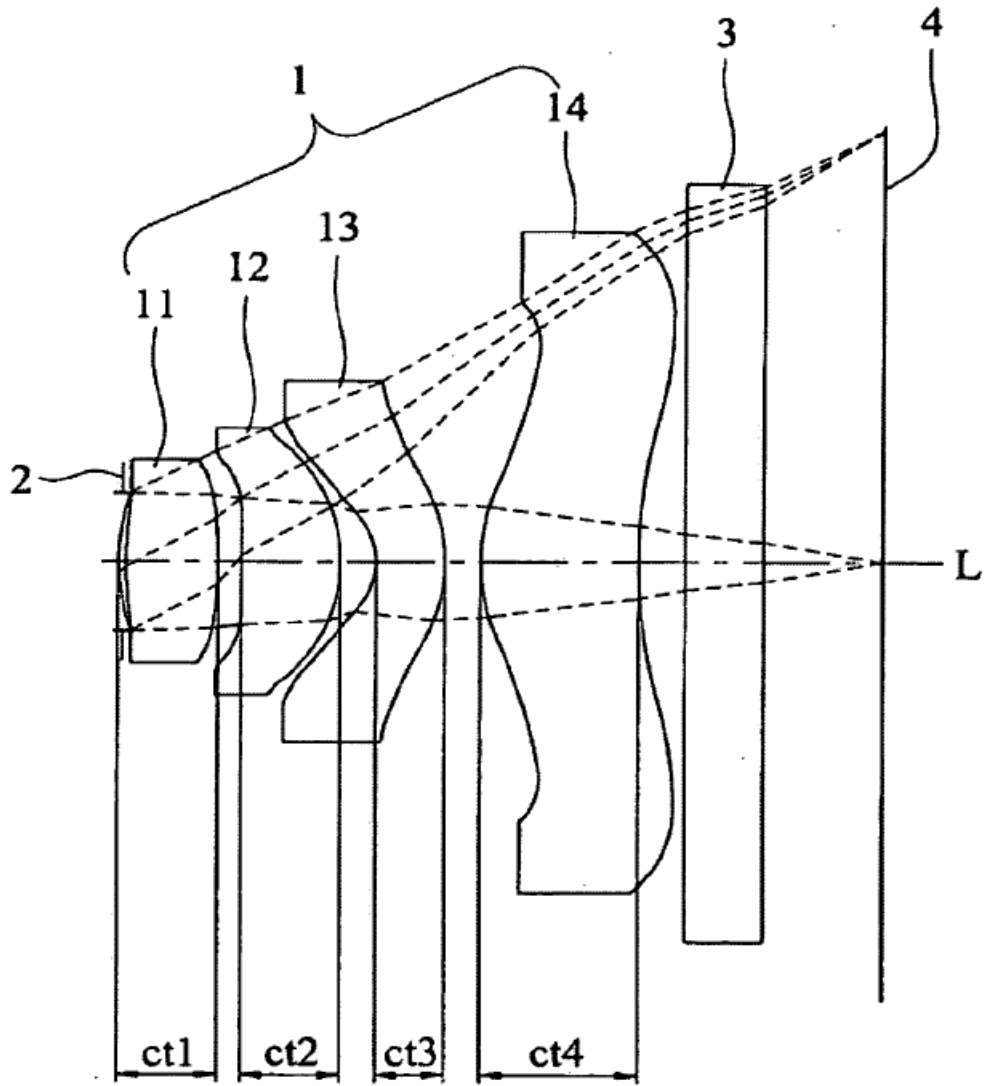


Fig. 7

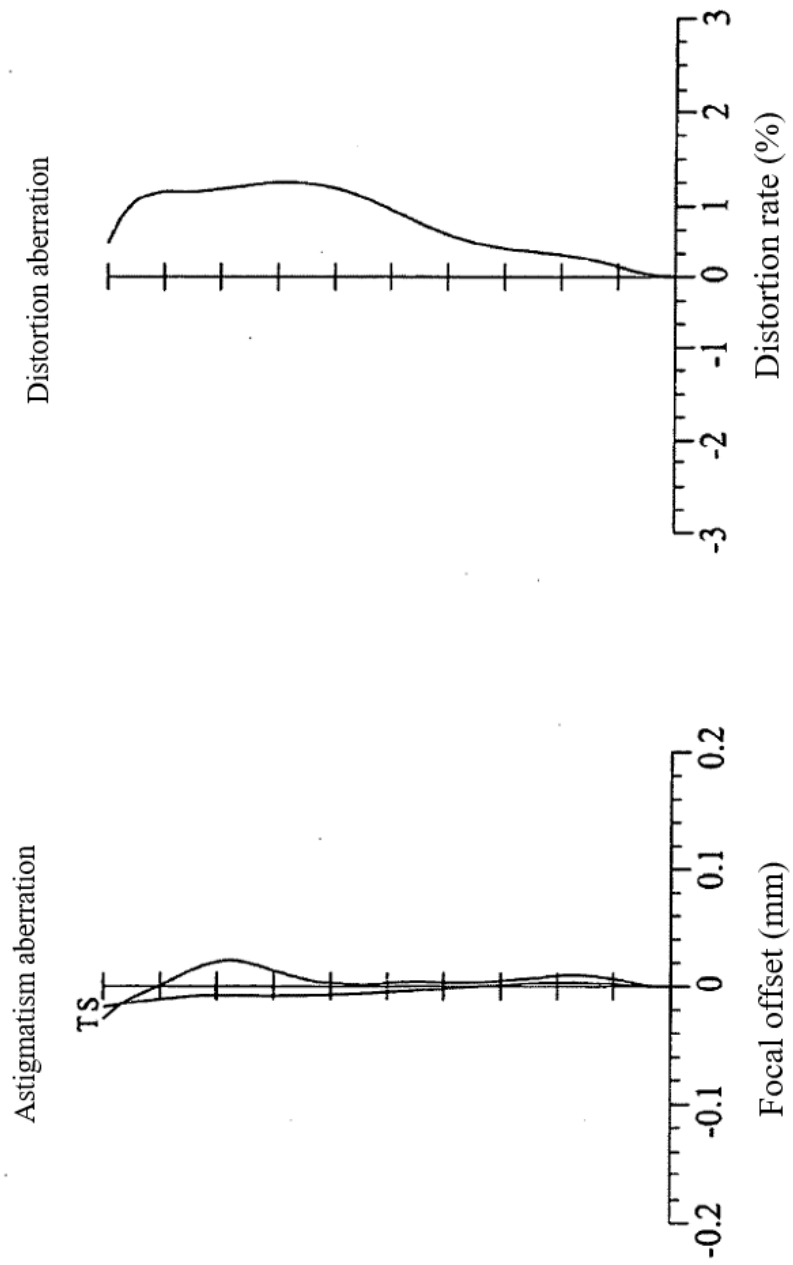


Fig. 8

Spherical aberration

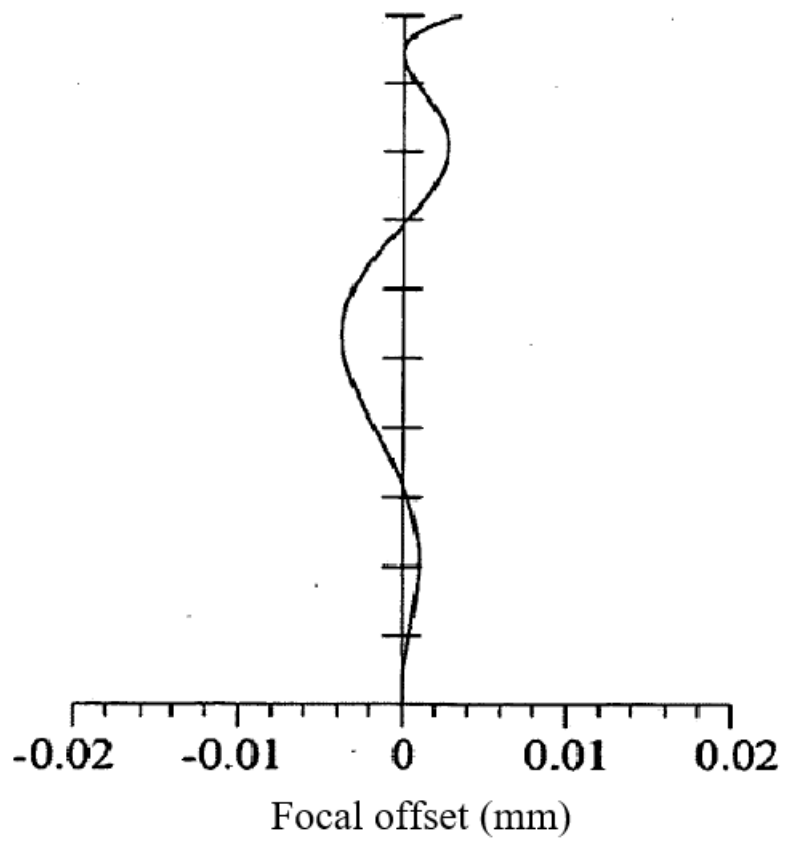
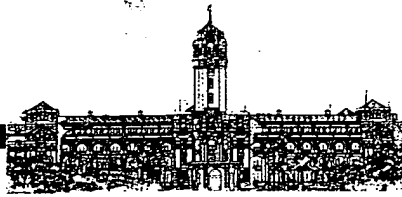


Fig. 9



中華民國經濟部智慧財產局

INTELLECTUAL PROPERTY OFFICE
MINISTRY OF ECONOMIC AFFAIRS
REPUBLIC OF CHINA

茲證明所附文件，係本局存檔中原申請案的副本，正確無訛，
其申請資料如下：

This is to certify that annexed is a true copy from the records of this office of
the application as originally filed which is identified hereunder：

申 請 日：西元 2013 年 09 月 02 日
Application Date Sep. 2, 2013

申 請 案 號：102131525
Application No.

申 請 人：先進光電科技股份有限公司
Applicant(s)

發 明 人：游鴻國
Inventor(s)

局 長

Director General

王美花

西元 2013 年 10 月 14 日
Oct. 14, 2013

發明摘要

※ 申請案號：

※ 申請日：

※IPC 分類：

【發明名稱】 薄型廣角四片式成像鏡頭組

【中文】

一種薄型廣角四片式成像鏡頭組包含一光學組及一固定光欄，光學組沿光軸從物側至像側依序包括第一、第二、第三及第四鏡片，屈光力為正正負正，第一鏡片朝向物側在靠近中心光軸附近為凸面，第二鏡片朝向像側在靠近中心光軸附近為凸面，第三鏡片朝向物側在靠近中心光軸附近為凹面且朝向像側在靠近中心光軸附近為凸面，第四鏡片朝向像側在靠近中心光軸附近為凹面，且從光軸至非球面終止點至少有一反曲點，固定光欄位於物側與第二鏡片間，滿足 $15 < \text{HFOV}/f < 50$ ，HFOV 為該鏡頭組最大使用之可視角度的一半， f 為成像鏡頭組焦距值，HFOV 值大及 f 值小可使整體鏡頭組體積更加緊密化並且提高解像力，因此本發明能兼具輕薄短小與高效能優勢。

【英文】

【代表圖】

【本案指定代表圖】：圖（ 1 ）。

【本代表圖之元件符號簡單說明】：

1	光學組	14	第四鏡片
11	第一鏡片	2	固定光欄
12	第二鏡片	ct1~ct4	厚度
13	第三鏡片		

【本案若有化學式時，請揭示最能顯示發明特徵的化學式】：

發明專利說明書

(本說明書格式、順序，請勿任意更動)

【發明名稱】 薄型廣角四片式成像鏡頭組

【技術領域】

【0001】 本發明是有關於一種成像鏡頭組，特別是指一種薄型廣角四片式成像鏡頭組。

【先前技術】

【0002】 以往的成像鏡頭組，是適用於行動電話、智慧型手機、平板電腦、筆記型電腦以及攝像頭等電子產品當中的成像鏡頭組。隨著此類電子產品不斷地發展，逐漸朝向輕薄短小的設計傾向，但又同時要求高效能，因此，連帶地使得成像鏡頭組朝向整體更加緊密化的薄型尺寸發展，而爲了提高解像力，成像鏡頭組也需要朝向更廣角的方向發展。

【0003】 而以往的成像鏡頭組，如專利 TW201215941A、TW201224568A、TW201239443A 等，雖然揭露有四片式的成像鏡頭組，但前揭專利的實施態樣均未能進一步滿足薄型、廣角的需求。

【0004】 因此，爲了能讓電子產品兼具輕薄短小與高效能的優勢，一種可以使整體更加緊密化的薄型尺寸，且能提高解像力的廣角成像鏡頭組爲目前市場所需。

【發明內容】

【0005】 因此，本發明之目的，即在提供一種可以使整

體更加緊密化的薄型尺寸，且能提高解像力的薄型廣角四片式成像鏡頭組。

【0006】 於是，本發明薄型廣角四片式成像鏡頭組，包含一個光學組，及一個固定光欄，該光學組沿一個光軸從物側至像側依序包括一個第一鏡片、一個第二鏡片、一個第三鏡片，及一個第四鏡片，該第一鏡片，具有在靠近中心光軸附近為正屈光力且朝向物側為凸面，且該第一鏡片至少有一面為非球面，該第二鏡片，具有在靠近中心光軸附近為正屈光力且朝向像側為凸面，且該第二鏡片至少有一面為非球面，該第三鏡片，具有在靠近中心光軸附近為負屈光力且朝向物側為凹面且朝向像側為凸面，且該第三鏡片至少有一面為非球面，該第四鏡片，具有在靠近中心光軸附近為正屈光力且朝向像側為凹面，且該第四鏡片的兩面都為非球面，且兩面至少一面從該光軸至非球面終止點至少有一個反曲點，該固定光欄位於物側與該第二鏡片間，其中，該薄型廣角四片式成像鏡頭組滿足條件：

【0007】 $15 < \text{HFOV}/f < 50$ ，

【0008】 HFOV 為該鏡頭組最大使用之可視角度的一半，單位為 $^{\circ}$ ， f 為該薄型廣角四片式成像鏡頭組的焦距值，單位為mm。

【0009】 本發明所述的薄型廣角四片式成像鏡頭組，其中，該薄型廣角四片式成像鏡頭組滿足條件：

【0010】 $\text{HFOV} > 35^{\circ}$ 。

【0011】 本發明所述的薄型廣角四片式成像鏡頭組，其

● 中，該薄型廣角四片式成像鏡頭組滿足條件：

【0012】 $f < 2.7 \text{ mm}$ 。

【0013】 本發明所述的薄型廣角四片式成像鏡頭組，其中，該薄型廣角四片式成像鏡頭組滿足條件：

【0014】 $Nd3 > 1.56$ ，

【0015】 $V3 < 29$ ，

【0016】 $Nd3$ 為該第三鏡片的折射率， $V3$ 為該第三鏡片的色散係數。

【0017】 本發明所述的薄型廣角四片式成像鏡頭組，其中，該薄型廣角四片式成像鏡頭組滿足條件：

【0018】 $Nd2 < 1.56$ ，

【0019】 $V2 > 29$ ，

【0020】 $Nd2$ 為該第二鏡片的折射率， $V2$ 為該第二鏡片的色散係數。

【0021】 本發明所述的薄型廣角四片式成像鏡頭組，其中，該薄型廣角四片式成像鏡頭組滿足條件：

【0022】 $0.8 < |f/f3| < 2.5$ ，

【0023】 $f3$ 為該第三鏡片的焦距值，單位為 mm 。

【0024】 本發明所述的薄型廣角四片式成像鏡頭組，其中，該薄型廣角四片式成像鏡頭組滿足條件：

【0025】 $0.3 < ct1/ct2 < 2.0$ ，

【0026】 $0 < ct3/ct4 < 1.0$ ，

【0027】 $ct1$ 為該第一鏡片的中心厚度， $ct2$ 為該第二鏡片的中心厚度， $ct3$ 為該第三鏡片的中心厚度， $ct4$ 為該第

四鏡片的中心厚度，單位皆為mm。

【0028】 本發明之功效在於該薄型廣角四片式成像鏡頭組滿足 $15 < \text{HFOV}/f < 50$ ，HFOV 值大代表本發明的可視角度相當大而能提高解像力，而 f 值小說明本發明是可使整體更加緊密化的薄型尺寸，因此本發明能讓電子產品兼具輕薄短小與高效能的優勢，而確實能滿足本發明的目的。

【圖式簡單說明】

【0029】 本發明之其他的特徵及功效，將於參照圖式的實施方式中清楚地呈現，其中：

圖 1 是一個光學結構示意圖，說明本發明薄型廣角四片式成像鏡頭組的第一具體實施例；

圖 2 是一個示意圖，說明本第一具體實施例的非點像差與歪曲像差；

圖 3 是一個示意圖，說明本第一具體實施例的球面像差；

圖 4 是一個光學結構示意圖，說明本發明薄型廣角四片式成像鏡頭組的第二具體實施例；

圖 5 是一個示意圖，說明本第二具體實施例的非點像差與歪曲像差；

圖 6 是一個示意圖，說明本第二具體實施例的球面像差；

圖 7 是一個光學結構示意圖，說明本發明薄型廣角四片式成像鏡頭組的第三具體實施例；

圖 8 是一個示意圖，說明本第三具體實施例的非點像差與歪曲像差；及

圖 9 是一個示意圖，說明本第三具體實施例的球面像差。

●【實施方式】

【0030】 參閱圖 1，本發明薄型廣角四片式成像鏡頭組包含一個光學組 1、一個固定光欄 2、一個濾鏡片 3，及一個成像面 4。

【0031】 該光學組 1 沿一個光軸 L 從物側至像側依序包括一個第一鏡片 11、一個第二鏡片 12、一個第三鏡片 13，及一個第四鏡片 14，該第一鏡片 11，具有在靠近中心光軸 L 附近為正屈光力且朝向物側為凸面，且該第一鏡片 11 至少有一面為非球面，該第二鏡片 12，具有在靠近中心光軸 L 附近為正屈光力且朝向像側為凸面，且該第二鏡片 12 至少有一面為非球面，該第三鏡片 13，具有在靠近中心光軸 L 附近為負屈光力且朝向物側為凹面且朝向像側為凸面，且該第三鏡片 13 至少有一面為非球面，該第四鏡片 14，具有在靠近中心光軸 L 附近為正屈光力且朝向像側為凹面，且該第四鏡片 14 的兩面都為非球面，且兩面至少一面從該光軸 L 至非球面終止點至少有一個反曲點，該固定光欄 2 位於物側與該第二鏡片 12 間，其中，該薄型廣角四片式成像鏡頭組滿足條件：

$$\text{【0032】 } 15 < \text{HFOV}/f < 50 \quad (1),$$

$$\text{【0033】 } 0.8 < |f/f_3| < 2.5 \quad (2),$$

$$\text{【0034】 } 0.3 < ct_1/ct_2 < 2.0 \quad (3),$$

$$\text{【0035】 } 0 < ct_3/ct_4 < 1.0 \quad (4),$$

【0036】 HFOV 為該鏡頭組最大使用之可視角度的一半，單位為°，f 為該薄型廣角四片式成像鏡頭組的焦距

值，單位為 mm， f_3 為該第三鏡片 13 的焦距值，單位為 mm， ct_1 為該第一鏡片 11 的中心厚度， ct_2 為該第二鏡片 12 的中心厚度， ct_3 為該第三鏡片 13 的中心厚度， ct_4 為該第四鏡片 14 的中心厚度，單位皆為 mm。

【0037】更佳地，該薄型廣角四片式成像鏡頭組滿足條件：

【0038】 $HFOV > 35^\circ$ (5)，

【0039】 $f < 2.7 \text{ mm}$ (6)，

【0040】條件式(1)說明 HFOV 值大代表本發明的可視角度相當大而能提高解像力，而 f 值小說明本發明是可使整體更加緊密化的薄型尺寸，而條件式(5)與條件式(6)則是進一步闡述了本發明的可視角度大以及薄型尺寸的優勢。

【0041】值得說明的是，該薄型廣角四片式成像鏡頭組滿足條件：

【0042】 $Nd_3 > 1.56$ (7)，

【0043】 $V_3 < 29$ (8)，

【0044】 $Nd_2 < 1.56$ (9)，

【0045】 $V_2 > 29$ (10)，

【0046】 Nd_3 為該第三鏡片 13 的折射率， V_3 為該第三鏡片 13 的色散係數， Nd_2 為該第二鏡片 12 的折射率， V_2 為該第二鏡片 12 的色散係數，條件式(7)至條件式(10)闡明了本發明由該第三鏡片 13 提供的屈光力大於該第二鏡片 12 所提供的屈光力。

【0047】附帶一提的是，本發明的非球面的面型滿足條

件：

$$z = \frac{ch^2}{1+[1-(k+1)c^2h^2]^{0.5}} + Ah^4 + Bh^6 + Ch^8 + Dh^{10} + Eh^{12} + Fh^{14} + Gh^{16} + Hh^{18} + Jh^{20} + \dots$$

【0048】

【0049】

(11)，

【0050】 其中， z 為沿該光軸 L 方向在高度為 h 的位置以表面頂點作參考的位置值， k 為錐常度量， c 為曲率半徑的倒數， A 、 B 、 C 、 D 、 E 、 F 、 G 、 H 、 J ……為高階非球面係數，非球面的面型在於可以矯正像差以及降低公差敏感度，也使本發明具有廣角效能。

【0051】 <第一具體實施例>

【0052】 配合參閱圖 1、圖 2 與圖 3，且本第一具體實施例的各項參數為： $f1=2.19$ mm， $f2=2.05$ mm， $f3=-1.16$ mm， $f4=1.52$ mm， $f=1.60$ mm， $ct1=0.284$ mm， $ct2=0.368$ mm， $ct3=0.190$ mm， $ct4=0.472$ mm， $HFOV=44^\circ$ 。

【0053】 本第一具體實施例滿足條件式(1)至(11)， $HFOV/f=27.5$ ， $|f/f3|=1.38$ ， $ct1/ct2=0.77$ ， $ct3/ct4=0.40$ ， $Nd2=1.535$ ， $Nd3=1.636$ ， $V2=56.07$ ， $V3=23.89$ 。

【0054】 圖 2 表現本第一具體實施例的非點像差與歪曲像差，圖 3 表現球面像差。

【0055】

第一具體實施例鏡片數據

表面		曲率半徑 (Radius)	厚度/間隔 (Thickness)	折射率 (Nd)	阿貝數 (Vd)	焦長 (mm)
固定光圈		∞	-0.03			
第一鏡片 11	第一面	1.361	0.284	1.535	56.07	2.19
	第二面	-8.119	0.194			
第二鏡片 12	第三面	-2.042	0.368	1.535	56.07	2.05
	第四面	-0.760	0.159			
第三鏡片 13	第五面	-0.289	0.190	1.636	23.89	-1.16
	第六面	-0.596	0.038			
第四鏡片 14	第七面	0.488	0.472	1.535	56.07	1.52
	第八面	0.805	0.25			
濾鏡片	第九面	∞	0.21	1.517	64.17	
	第十面	∞	0.332			

【0056】 第一具體實施例非球面參數為：

【0057】

	第一面	第二面	第三面	第四面	第五面	第六面	第七面	第八面
k	0	0	6.191788	-3.784132	-3.838175	-1.077898	-7.06691	-2.241616
A	-0.2065838	-0.7720604	-1.4905075	-1.1446487	-4.9202522	-0.5217609	0.10412867	-0.3678477
B	-3.3390093	1.4937038	13.548352	-13.499105	18.914991	0.96784978	-1.6835431	0.10715581
C	45.617387	-48.87327	-222.85883	142.67618	-20.771041	12.065814	4.2811759	0.31062561
D	-568.5172	417.56966	1762.543	-811.19607	12.125511	-36.497597	-6.3438122	-0.5323217
E	3836.6411	-1866.3668	-7503.2608	2964.6502	-142.85927	22.957229	5.6351203	0.37789525
F	-14300.609	3693.0414	17228.893	-6161.6996	243.02698	33.940443	-2.7711759	-0.1331061
G	22470.012	-1072.5651	-16174.808	5342.7346	30.761799	-33.635537	0.58039414	0.018683511

【0058】 <第二具體實施例>

【0059】 配合參閱圖 3、圖 4 與圖 5，且本第二具體實施

例的各項參數為： $f_1=2.39$ mm， $f_2=2.08$ mm， $f_3=-1.45$ mm， $f_4=1.85$ mm， $f=1.60$ mm， $ct_1=0.276$ mm， $ct_2=0.392$ mm， $ct_3=0.204$ mm， $ct_4=0.450$ mm， $HFOV=44^\circ$ 。

【0060】本第二具體實施例滿足條件式(1)至(11)
 $HFOV/f=27.5$ ， $|f/f_3|=1.10$ ， $ct_1/ct_2=0.70$ ， $ct_3/ct_4=0.45$ ，
 $Nd_2=1.535$ ， $Nd_3=1.636$ ， $V_2=56.07$ ， $V_3=23.89$ 。

【0061】圖4表現本第二具體實施例的非點像差與歪曲像差，圖5表現球面像差。

【0062】

第二具體實施例鏡片數據						
表面		曲率半徑 (Radius)	厚度/間隔 (Thickness)	折射率 (Nd)	阿貝數 (Vd)	焦長 (mm)
第一鏡片 11	第一面	1.172	0.276	1.535	56.07	2.39
	第二面	12.524	0.002			
固定光圈		∞	0.193			
第二鏡片 12	第三面	-2.352	0.392	1.535	56.07	2.08
	第四面	-0.800	0.165			
第三鏡片 13	第五面	-0.295	0.204	1.636	23.89	-1.45
	第六面	-0.550	0.022			
第四鏡片 14	第七面	0.526	0.450	1.535	56.07	1.85
	第八面	0.786	0.25			
濾鏡片	第九面	∞	0.21	1.517	64.17	
	第十面	∞	0.352			

【0063】第二具體實施例非球面參數為：

【0064】

	第一面	第二面	第三面	第四面	第五面	第六面	第七面	第八面
k	-27.67006	0	0	-0.1133277	-3.670904	-1.681659	-7.045281	-3.872049
A	1.9885098	-0.37701082	-0.96274237	-0.00025411	-3.9824733	-0.37652375	0.000309204	-0.15744128
B	-16.754161	-0.49422655	2.5787486	-13.638266	9.3522783	-3.5402459	-1.3786241	-0.21216838
C	121.87784	-25.697915	-75.20593	119.14826	-14.277191	22.786238	3.9107049	0.6311134
D	-697.96568	372.82808	563.02784	-775.83633	58.628841	-34.875393	-6.1155891	-0.74118053
E	2523.3236	-3090.4143	-2537.022	3121.5568	13.198369	-6.5038799	5.4923776	0.45196807
F	-5159.4568	12641.659	4107.643	-6765.6192	-631.1631	60.790568	-2.5266688	-0.14266076
G	4272.9124	-20091.048	1821.596	6044.1686	956.17439	-37.919506	0.51902791	0.01825282

【0065】 <第三具體實施例>

【0066】 配合參閱圖 6、圖 7 與圖 8，且本第三具體實施例的各項參數為： $f_1=2.55$ mm， $f_2=0.86$ mm， $f_3=-0.61$ mm， $f_4=0.98$ mm， $f=1.13$ mm， $ct_1=0.239$ mm， $ct_2=0.266$ mm， $ct_3=0.187$ mm， $ct_4=0.429$ mm， $HFOV=44^\circ$ 。

【0067】 本第三具體實施例滿足條件式(1)至(11)
 $HFOV/f=39.0$ ， $|f/f_3|=1.85$ ， $ct_1/ct_2=0.90$ ， $ct_3/ct_4=0.44$ ，
 $Nd_2=1.535$ ， $Nd_3=1.636$ ， $V_2=56.07$ ， $V_3=23.89$ 。

【0068】 圖 7 表現本第三具體實施例的非點像差與歪曲像差，圖 8 表現球面像差。

【0069】

第三具體實施例鏡片數據						
表面		曲率半徑 (Radius)	厚度/間隔 (Thickness)	折射率 (Nd)	阿貝數 (Vd)	焦長 (mm)
固定光圈		∞	-0.001			
第一鏡片 11	第一面	1.903	0.239	1.535	56.07	2.55
	第二面	-4.616	0.062			

第二鏡片 12	第三面	3.029	0.266	1.535	56.07	0.86
	第四面	-0.528	0.095			
第三鏡片 13	第五面	-0.184	0.187	1.636	23.89	-0.61
	第六面	-0.483	0.092			
第四鏡片 14	第七面	0.430	0.429	1.535	56.07	0.98
	第八面	1.549	0.125			
濾鏡片	第九面	∞	0.210	1.517	64.17	
	第十面	∞	0.325			

【0070】 第三具體實施例非球面參數為：

【0071】

	第一面	第二面	第三面	第四面	第五面	第六面	第七面	第八面
k	8.58328	-2824.922	42.97767	0.7395685	-1.926854	-0.3569793	-5.810289	1.443596
A	-1.2031657	-9.8439198	-7.1130345	0.63242517	-4.0319876	-0.15762397	-0.05755995	-0.20237191
B	12.223278	116.10956	4.0234552	-132.3459	-130.00916	3.7724173	-1.4813813	0.7721049
C	-1918.3111	-1775.4567	-507.43521	2590.488	3983.5728	116.23539	9.9370396	-8.9338663
D	6722.3948	-15124.178	-7707.7496	-20847.637	-22497.967	-218.09901	-60.63752	26.574088
E	2123163.2	652775.39	80989.53	138170.7	-103474.15	-4855.6445	190.69088	-38.350854
F	-52922573	-5158083.1	1130631.4	-1000249.5	1277642.5	24221.919	-287.85565	27.456949
G	3.7786e+008	11596365	-8089358.7	3411687.3	-3002346	-32489.178	163.69987	-8.006268

【0072】 綜上所述，本發明之功效如下：

【0073】 一、本發明的特徵在於該薄型廣角四片式成像鏡頭組滿足 $15 < \text{HFOV}/f < 50$ ，此外，本發明也藉由滿足條件式(2)至(11)來提高解像力、提高廣角角度、降低厚度更加薄型化。

【0074】 二、HFOV 值大代表本發明的可視角度相當大

而能提高解像力。

【0075】 三、 f 值小說明本發明是可使整體更加緊密化的薄型尺寸。

【0076】 本發明能讓電子產品兼具輕薄短小與高效能的優勢，而確實能滿足本發明的目的。

【0077】 惟以上所述者，僅為本發明之較佳實施例而已，當不能以此限定本發明實施之範圍，即大凡依本發明申請專利範圍及專利說明書內容所作之簡單的等效變化與修飾，皆仍屬本發明專利涵蓋之範圍內。

● 【符號說明】

【0078】

1光學組

11第一鏡片

12第二鏡片

13第三鏡片

14第四鏡片

2固定光欄

3濾鏡片

4成像面

L光軸

ct1~ct4厚度

【生物材料寄存】

國內寄存資訊【請依：寄存機構、日期、號碼順序註記】

國外寄存資訊【請依：寄存國家、機構、日期、號碼順序註記】

【序列表】(請換頁單獨記載)

申請專利範圍

1. 一種薄型廣角四片式成像鏡頭組，包含：

一個光學組，該光學組沿一個光軸從物側至像側依序包括一個第一鏡片、一個第二鏡片、一個第三鏡片，及一個第四鏡片，

該第一鏡片，具有在靠近中心光軸附近為正屈光力且朝向物側為凸面，且該第一鏡片至少有一面為非球面，

該第二鏡片，具有在靠近中心光軸附近為正屈光力且朝向像側為凸面，且該第二鏡片至少有一面為非球面，

該第三鏡片，具有在靠近中心光軸附近為負屈光力且朝向物側為凹面且朝向像側為凸面，且該第三鏡片至少有一面為非球面，

該第四鏡片，具有在靠近中心光軸附近為正屈光力且朝向像側為凹面，且該第四鏡片的兩面都為非球面，且兩面至少一面從該光軸至非球面終止點至少有一個反曲點；及

一個固定光欄，位於物側與該第二鏡片間，

其中，該薄型廣角四片式成像鏡頭組滿足條件：

$$15 < \text{HFOV}/f < 50,$$

HFOV 為該鏡頭組最大使用之可視角度的一半，單位為°，f 為該薄型廣角四片式成像鏡頭組的焦距值，單位為 mm。

2. 如請求項 1 所述的薄型廣角四片式成像鏡頭組，其中，
該薄型廣角四片式成像鏡頭組滿足條件：
 $HFOV > 35^\circ$ 。
3. 如請求項 1 所述的薄型廣角四片式成像鏡頭組，其中，
該薄型廣角四片式成像鏡頭組滿足條件：
 $f < 2.7 \text{ mm}$ 。
4. 如請求項 1 所述的薄型廣角四片式成像鏡頭組，其中，
該薄型廣角四片式成像鏡頭組滿足條件：
 $Nd3 > 1.56$ ，
 $V3 < 29$ ，
 $Nd3$ 為該第三鏡片的折射率， $V3$ 為該第三鏡片的色散係數。
5. 如請求項 4 所述的薄型廣角四片式成像鏡頭組，其中，
該薄型廣角四片式成像鏡頭組滿足條件：
 $Nd2 < 1.56$ ，
 $V2 > 29$ ，
 $Nd2$ 為該第二鏡片的折射率， $V2$ 為該第二鏡片的色散係數。
6. 如請求項 1 所述的薄型廣角四片式成像鏡頭組，其中，
該薄型廣角四片式成像鏡頭組滿足條件：
 $0.8 < |f/f3| < 2.5$ ，
 $f3$ 為該第三鏡片的焦距值，單位為 mm。
7. 如請求項 1 所述的薄型廣角四片式成像鏡頭組，其中，
該薄型廣角四片式成像鏡頭組滿足條件：

$$0.3 < ct1/ct2 < 2.0,$$

$$0 < ct3/ct4 < 1.0,$$

ct1 為該第一鏡片的中心厚度，ct2 為該第二鏡片的中心厚度，ct3 為該第三鏡片的中心厚度，ct4 為該第四鏡片的中心厚度，單位皆為 mm。

圖式

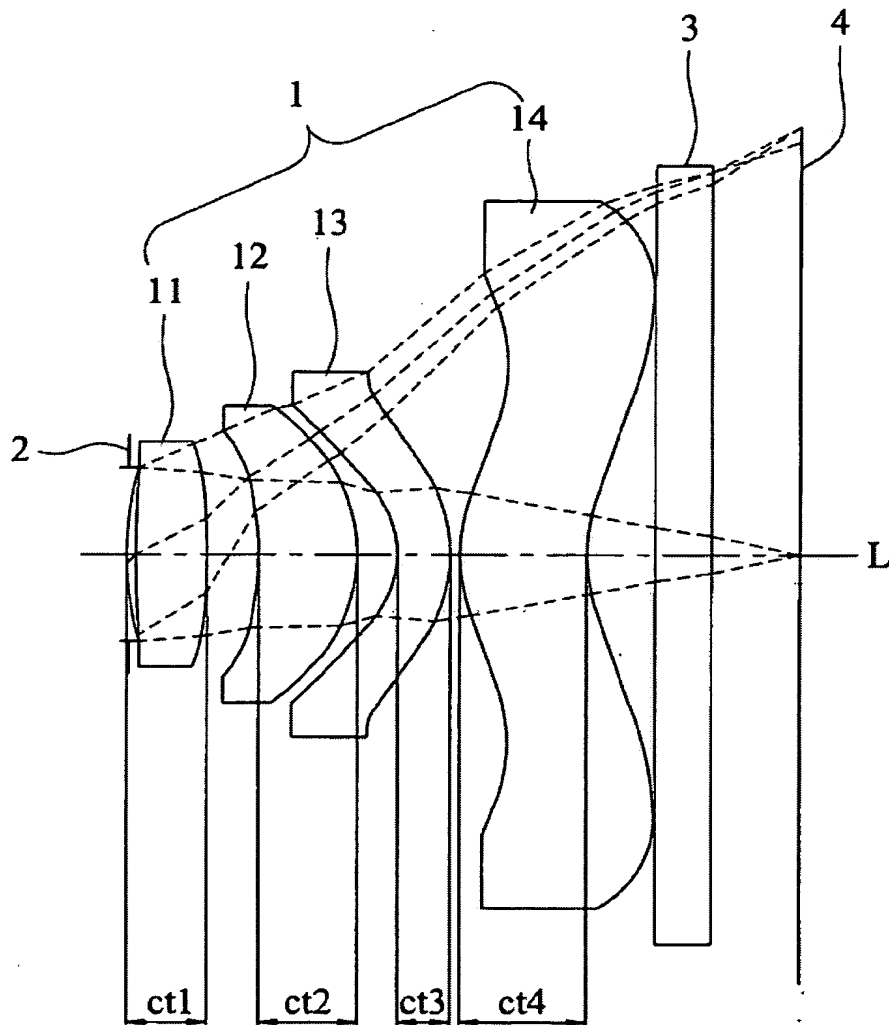


圖1

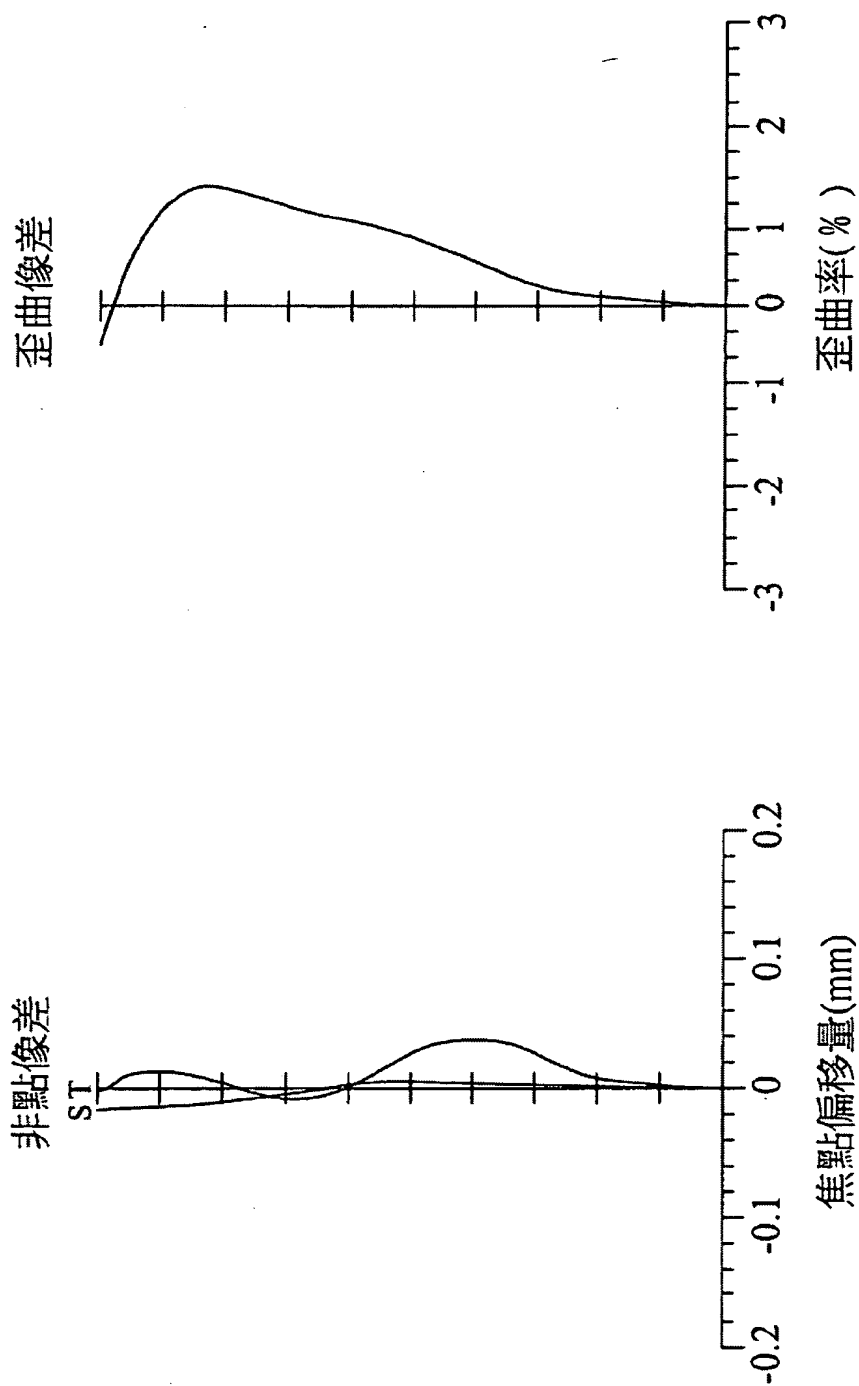


圖2

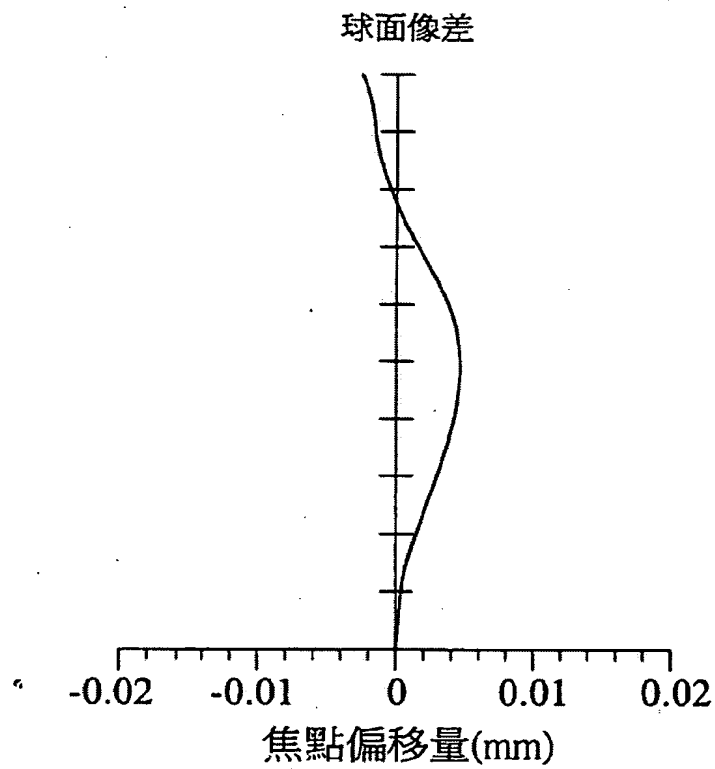


圖3

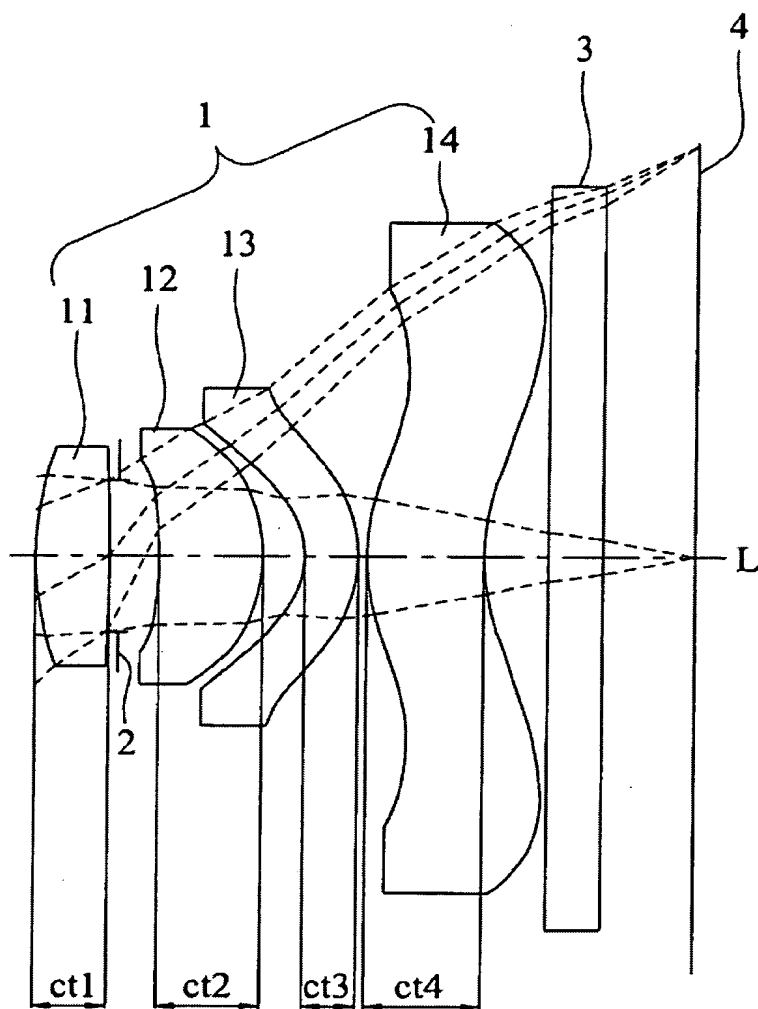


圖4

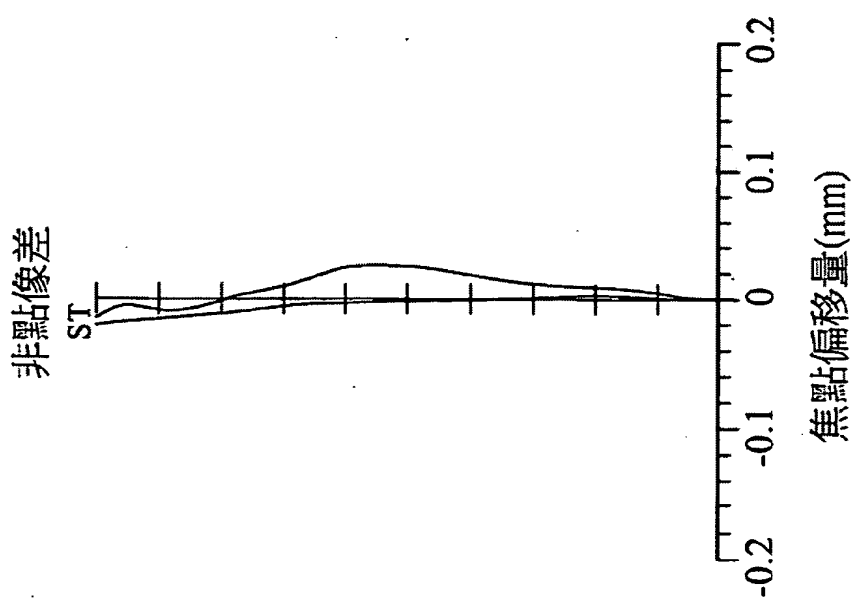
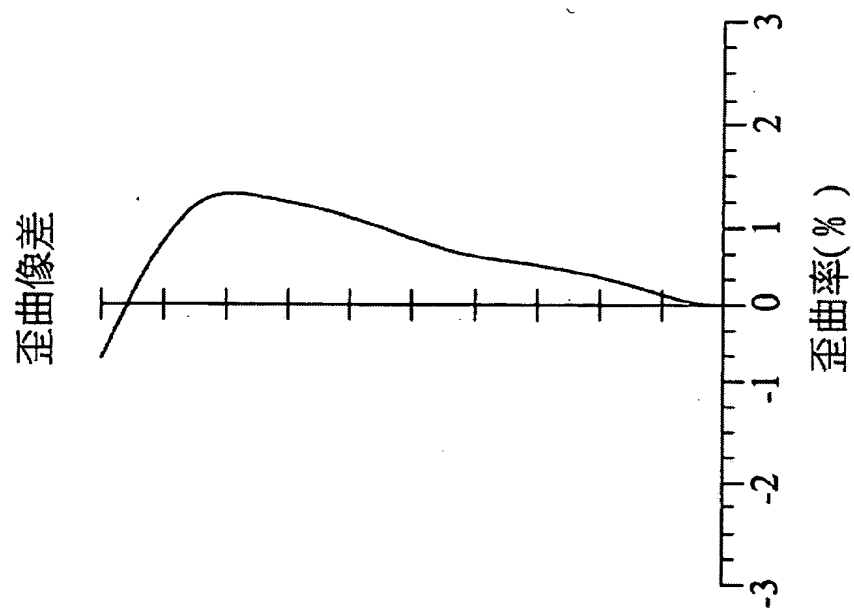


圖5

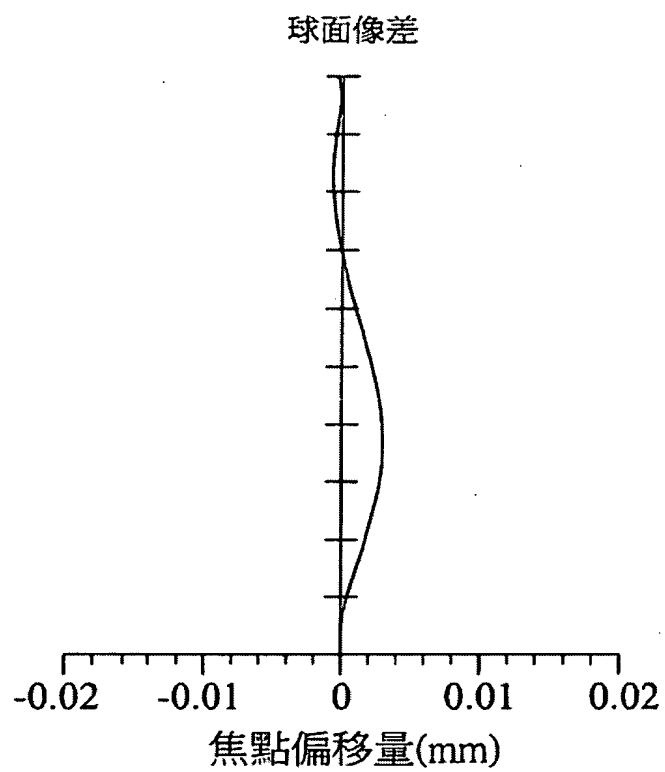


圖6

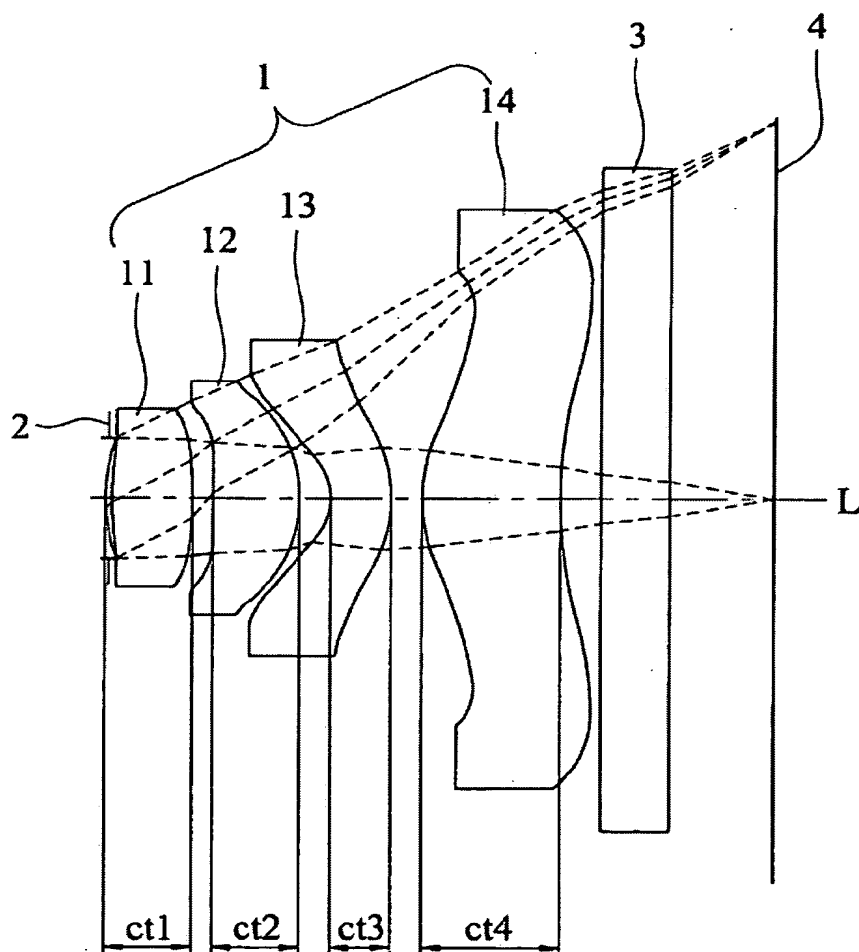


圖7

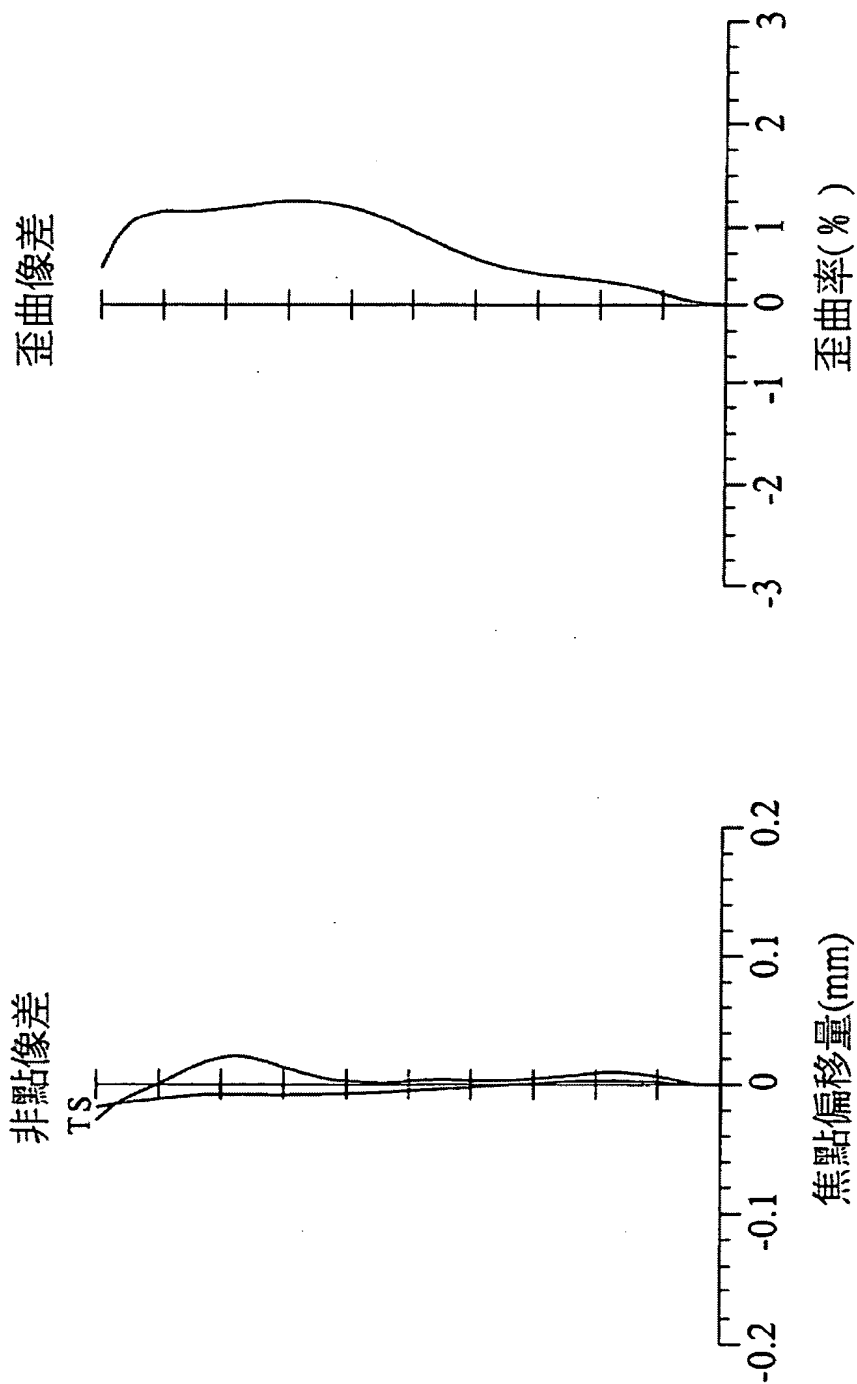


圖8

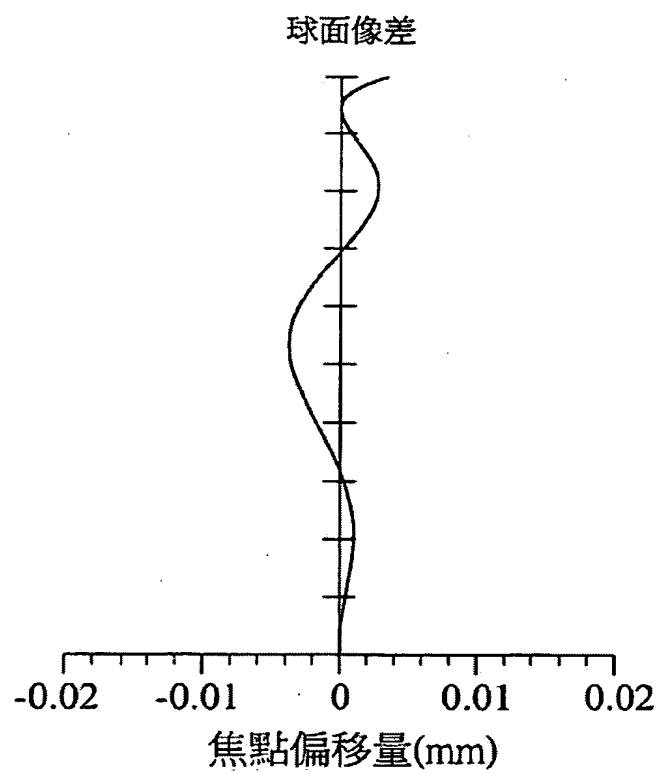


圖9