US009671589B2

(12) United States Patent
Chen et al.

(10) Patent No.: US 9,671,589 B2

(45) Date of Patent: Jun. 6, 2017

(54) **MOBILE DEVICE AND OPTICAL IMAGING LENS THEREOF**

(71) Applicant: **GeniuS Electronic Optical Co., Ltd.**, Taichung (TW)

(72) Inventors: **Shih-Han Chen**, Taichung (TW); **Ta-Cheng Fan**, Taichung (TW); **Jia Sin Jhang**, Taichung (TW)

(73) Assignee: **GeniuS Electronic Optical Co., Ltd.**, Taichung (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/696,203**

(22) Filed: **Apr. 24, 2015**

(65) **Prior Publication Data**

US 2016/0216484 A1 Jul. 28, 2016

(30) **Foreign Application Priority Data**

Jan. 23, 2015 (CN) 2015 1 0034278

(51) **Int. Cl.**

G02B 13/18	(2006.01)
G02B 9/64	(2006.01)
G02B 13/00	(2006.01)
G02B 5/00	(2006.01)
G02B 27/00	(2006.01)
G02B 9/62	(2006.01)
G02B 3/04	(2006.01)

(52) **U.S. Cl.**

CPC ***G02B 13/0045*** (2013.01); ***G02B 9/64*** (2013.01); *G02B 3/04* (2013.01); *G02B 5/005* (2013.01); *G02B 9/62* (2013.01); *G02B 13/001* (2013.01); *G02B 13/002* (2013.01); *G02B 13/0015* (2013.01); *G02B 13/18* (2013.01); *G02B 27/0025* (2013.01)

(58) **Field of Classification Search**

CPC G02B 13/0045; G02B 9/62; G02B 13/18; G02B 27/0025; G02B 13/0015; G02B 5/005; G02B 3/04; G02B 9/64; G02B 13/002; G02B 13/001

USPC 359/713, 739, 756, 757

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2013/0329306 A1* 12/2013 Tsai G02B 13/0045 359/713

2014/0355134 A1 12/2014 Sekine

FOREIGN PATENT DOCUMENTS

CN	203909381	10/2014
TW	201239446	10/2012
TW	201447357	12/2014

* cited by examiner

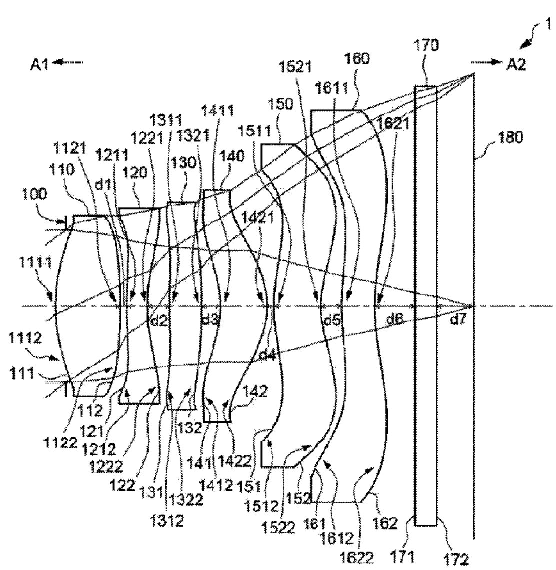
Primary Examiner — Evelyn A Lester

(74) *Attorney, Agent, or Firm* — Baker & McKenzie LLP

(57) **ABSTRACT**

Present embodiments provide for a mobile device and an optical imaging lens thereof. The optical imaging lens may comprise an aperture stop and six lens elements positioned sequentially from an object side to an image side. Through controlling the convex or concave shape of the surfaces of the lens elements and designing parameters satisfying at least one inequality, the optical imaging lens may exhibit better optical characteristics and the total length of the optical imaging lens may be shortened.

14 Claims, 47 Drawing Sheets



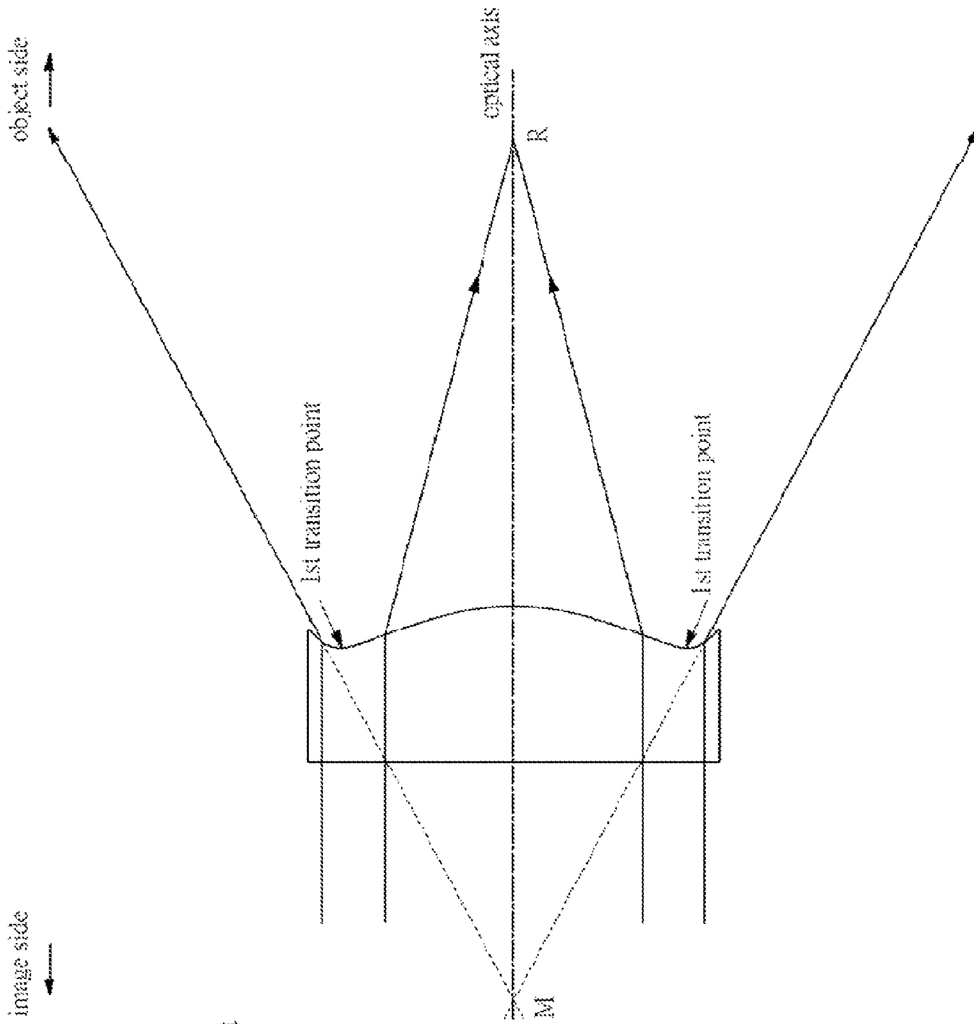

object side
image side
optical axis
R
M
1st transition point
1st transition point

FIG. 2

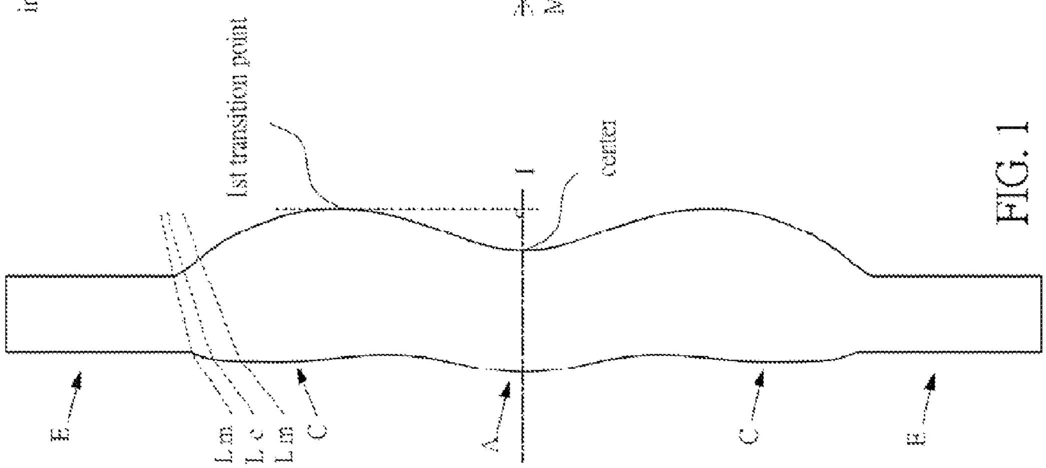

1st transition point
center
I
E
L m
L c
L m
C
A
C
E

FIG. 1

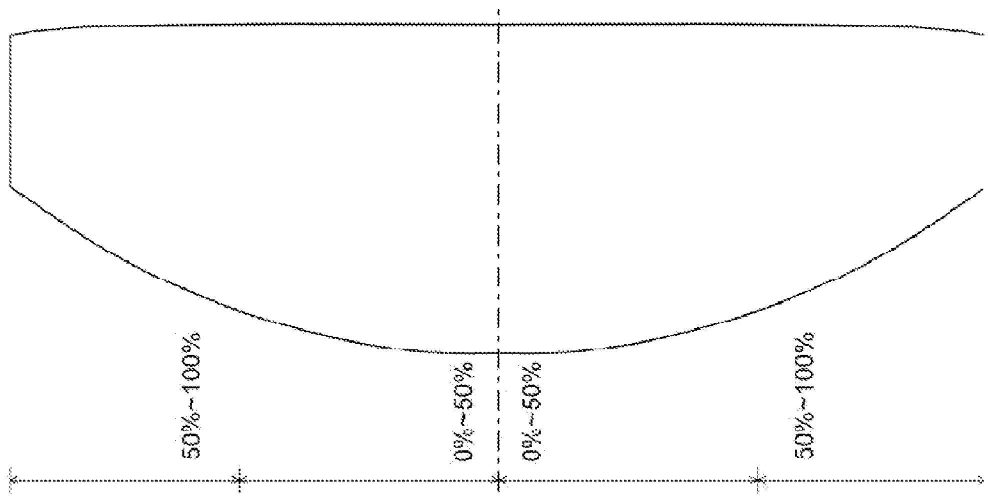


FIG. 5

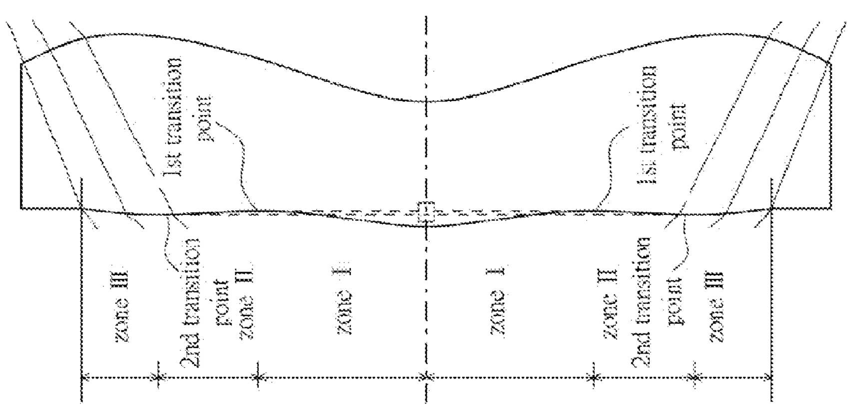


FIG. 4

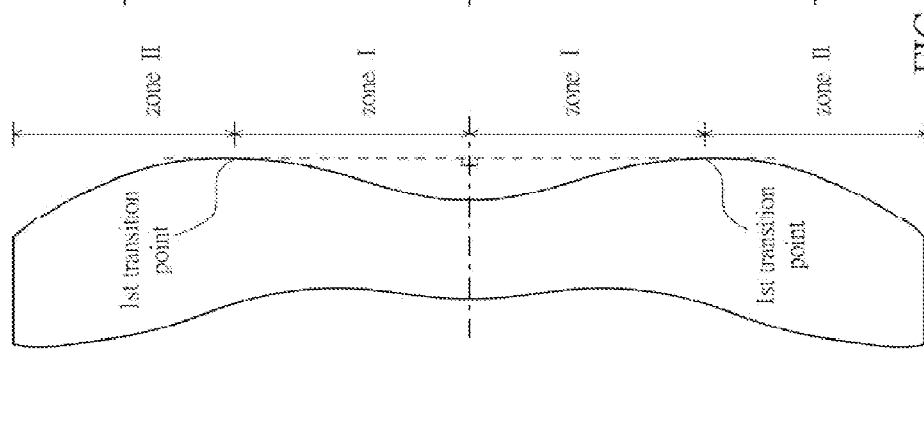
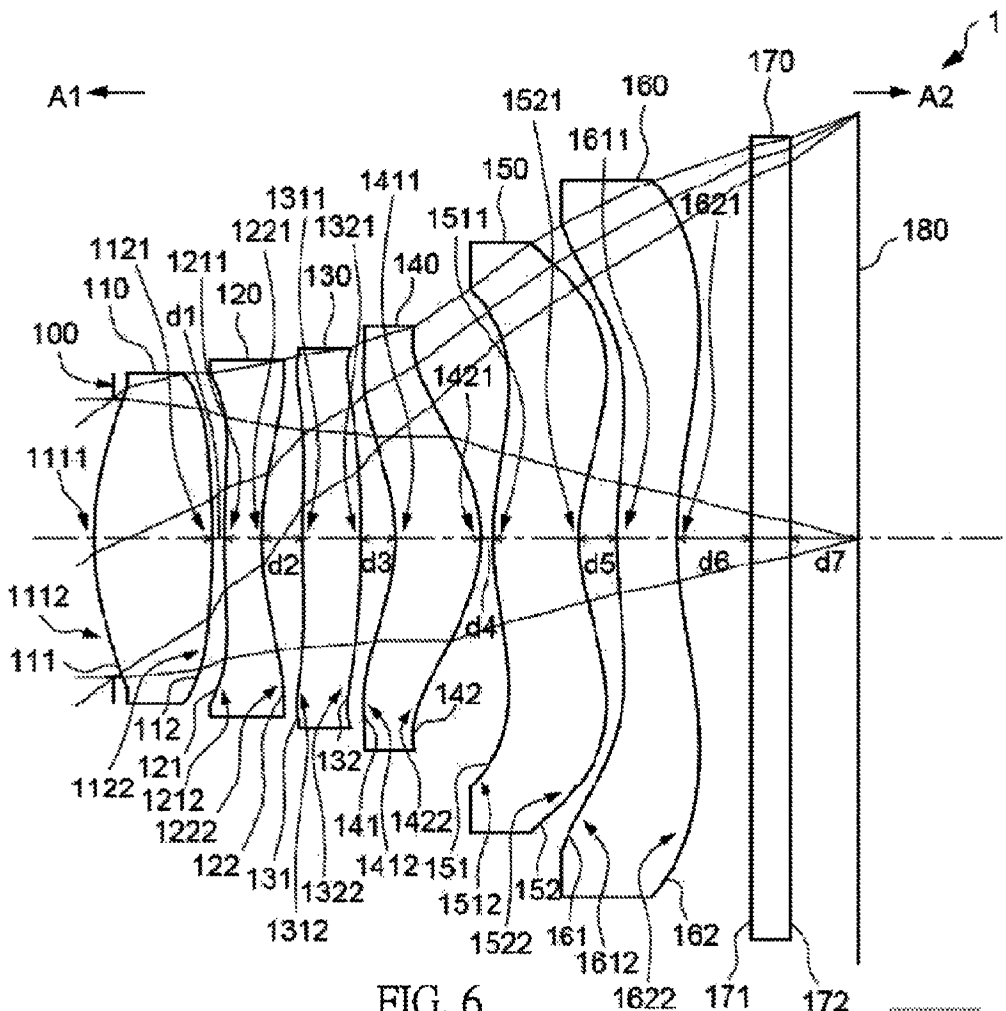
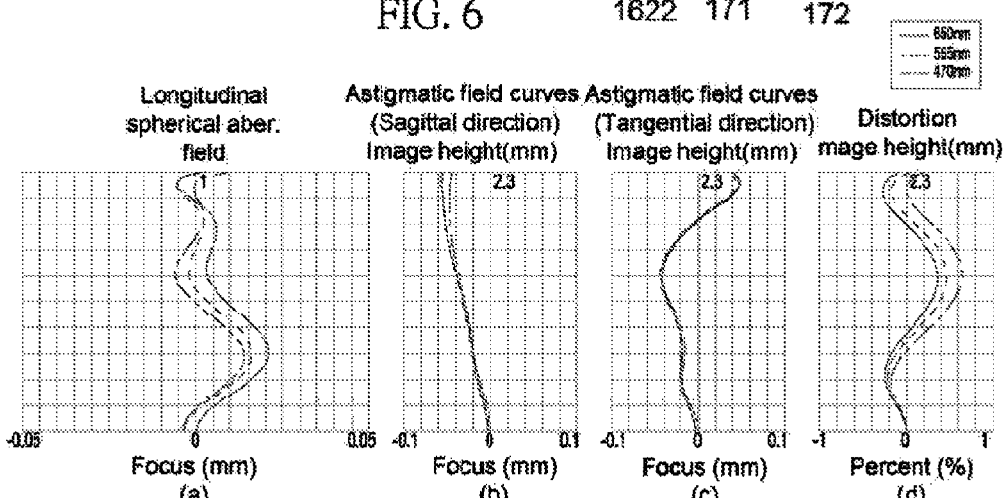


FIG. 3



A1
A2
1
100
110
111
112
120
121
122
130
131
132
140
141
142
150
151
152
160
161
162
170
171
172
180
1111
1112
1121
1122
1211
1212
1221
1222
1311
1312
1321
1322
1411
1412
1421
1422
1511
1512
1521
1522
1611
1612
1621
1622
d1
d2
d3
d4
d5
d6
d7

FIG. 6



650nm
555nm
470nm
Longitudinal spherical aber.
field
1
-0.05
0
0.05
Focus (mm)
(a)
Astigmatic field curves (Sagittal direction)
Image height(mm)
2.3
-0.1
0
0.1
Focus (mm)
(b)
Astigmatic field curves (Tangential direction)
Image height(mm)
2.3
-0.1
0
0.1
Focus (mm)
(c)
Distortion
mage height(mm)
2.3
-1
0
1
Percent (%)
(d)

FIG. 7

EFL(Effective focus length)= 3.016mm, HFOV(Half angular field of view)= 37.286deg., System length=4.132mm, Image heigh= 2.3mm, Fno=2.0							
Surface #		Radius	Thickness	Refractive index	Abbe number	Focus	Material
-	Object	∞	∞				
100	Aperture stop	∞	-0.100				
111	1st lens element	1.778	0.637	1.535	55.712	2.401	plastic
112		-4.097	0.068				
121	2nd lens element	7.495	0.200	1.643	22.437	-3.429	plastic
122		1.696	0.224				
131	3rd lens element	8.453	0.315	1.535	55.712	7.088	plastic
132		-6.829	0.185				
141	4th lens element	-1.016	0.462	1.535	55.712	4.245	plastic
142		-0.814	0.069				
151	5th lens element	1.655	0.461	1.535	55.712	-5.314	plastic
152		0.946	0.206				
161	6th lens element	2.839	0.329	1.531	55.744	-22.608	plastic
162		2.205	0.400				
171	IR cut filter	∞	0.210	1.517	64.167		plastic
172		∞	0.366				
180	Image plane	∞	0.000				

FIG. 8

Aspherical parameters						
Surface #	111	112	121	122	131	132
K	-1.7391E+01	-1.5803E+02	0.0000E+00	-2.1411E+01	0.0000E+00	0.0000E+00
a_4	3.2460E-01	-5.0687E-03	5.1441E-02	2.7054E-01	-1.8783E-01	-5.9520E-02
a_6	-4.3419E-01	-1.4204E-01	-4.1133E-01	-6.0680E-01	-3.2825E-02	-3.7801E-02
a_8	3.2538E-01	-2.4450E-01	-2.0618E-01	2.8898E-01	1.0750E-01	8.3950E-02
a_{10}	-1.6884E-01	7.6504E-02	2.0760E-01	1.1895E-01	3.1968E-02	2.0227E-02
a_{12}	2.0131E-01	2.8924E-01	3.9413E-01	-8.4866E-02	0.0000E+00	0.0000E+00
a_{14}	-3.4095E-01	9.9061E-02	-6.5917E-02	-1.9603E-01	0.0000E+00	0.0000E+00
a_{16}	4.2021E-02	-3.2803E-01	-1.5414E-01	1.8859E-01	0.0000E+00	0.0000E+00
Surface #	141	142	151	152	161	162
K	-5.2634E+00	-1.6406E+00	-1.2539E+01	-7.2028E+00	0.0000E+00	0.0000E+00
a_4	-1.1107E-02	1.4831E-01	-1.3844E-01	-1.6002E-01	-1.9568E-01	-1.6517E-01
a_6	3.4967E-01	-1.0386E-01	3.3336E-02	4.2041E-02	2.0601E-02	4.6547E-02
a_8	-2.9350E-01	7.2326E-02	-9.2030E-03	-1.8319E-02	7.2636E-03	-8.9813E-03
a_{10}	2.1187E-01	1.4178E-01	-2.0523E-03	2.5718E-03	-1.1654E-03	4.8764E-04
a_{12}	-2.0208E-01	-1.2887E-01	-2.3634E-03	3.0723E-04	0.0000E+00	0.0000E+00
a_{14}	9.3880E-02	1.2079E-02	-3.4405E-04	-1.5305E-04	0.0000E+00	0.0000E+00
a_{16}	-1.5435E-02	8.6700E-03	8.6246E-04	5.1847E-05	0.0000E+00	0.0000E+00

FIG. 9

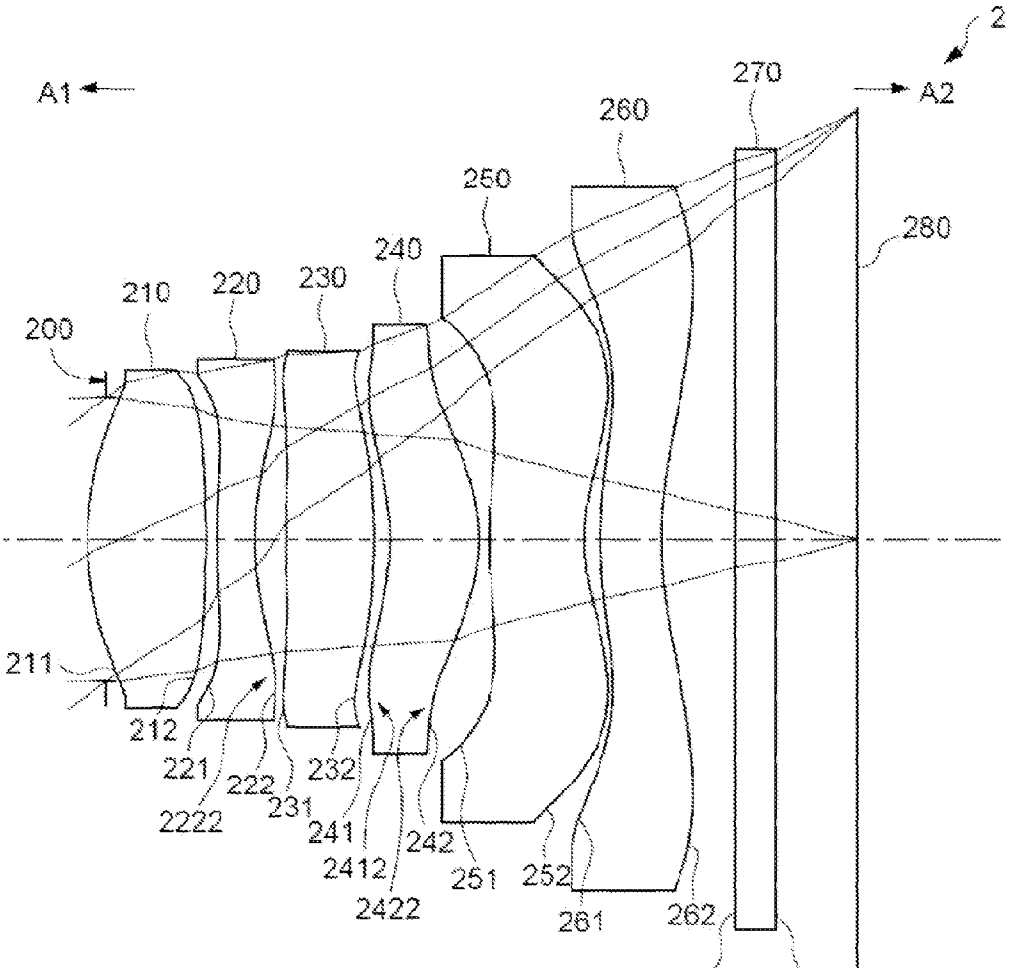

2
A1
A2
200
210
220
230
240
250
260
270
280
211
212
221
222
2222
231
232
241
2412
242
2422
251
252
261
262
271
272

FIG. 10

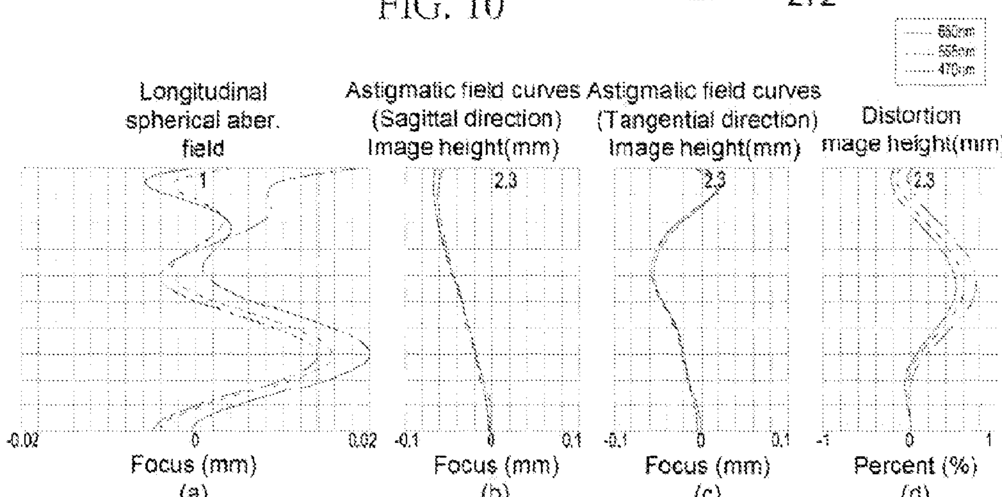

650nm
555nm
470nm
Longitudinal spherical aber. field
Astigmatic field curves (Sagittal direction) Image height(mm)
Astigmatic field curves (Tangential direction) Image height(mm)
Distortion Image height(mm)
1
2.3
2.3
2.3
-0.02
0
0.02
-0.1
0
0.1
-0.1
0
0.1
-1
0
1
Focus (mm)
(a)
Focus (mm)
(b)
Focus (mm)
(c)
Percent (%)
(d)

FIG. 11

EFL(Effective focus length)= 3.037mm, HFOV(Half angular field of view)= 37.125deg., System length=4.132mm, Image heigh= 2.3mm, Fno=2.0							
Surface #		Radius	Thickness	Refractive index	Abbe number	Focus	Material
-	Object	∞	∞				
200	Aperture stop	∞	-0.100				
211	1st lens element	1.681	0.638	1.535	55.712	2.447	plastic
212		-5.207	0.057				
221	2nd lens element	5.693	0.205	1.643	22.437	-3.537	plastic
222		1.611	0.168				
231	3rd lens element	11.414	0.469	1.535	55.712	5.346	plastic
232		-3.779	0.089				
241	4th lens element	-1.200	0.477	1.535	55.712	4.694	plastic
242		-0.926	0.051				
251	5th lens element	2.175	0.512	1.535	55.712	-3.794	plastic
252		0.965	0.088				
261	6th lens element	2.302	0.328	1.531	55.744	-267.215	plastic
262		2.153	0.400				
271	IR cut filter	∞	0.210	1.517	64.167		plastic
272		∞	0.441				
280	Image plane	∞	0.000				

FIG. 12

Aspherical parameters						
Surface #	211	212	221	222	231	232
K	-1.5505E+01	-2.6436E+02	0.0000E+00	-1.7851E+01	0.0000E+00	0.0000E+00
a_4	3.4620E-01	-1.4076E-03	-2.2954E-02	2.5259E-01	-1.4332E-01	-8.1449E-02
a_6	-4.3114E-01	-1.4892E-01	-4.2860E-01	-6.4207E-01	-2.1381E-02	8.0086E-04
a_8	3.2692E-01	-2.6061E-01	-1.7950E-01	2.8746E-01	1.1196E-01	1.0475E-01
a_{10}	-1.6138E-01	9.1852E-02	2.3806E-01	1.3026E-01	1.8970E-02	3.2768E-02
a_{12}	1.9936E-01	3.2901E-01	4.0478E-01	-8.2094E-02	0.0000E+00	0.0000E+00
a_{14}	-3.5535E-01	1.1208E-01	-8.5520E-02	-2.0037E-01	0.0000E+00	0.0000E+00
a_{16}	8.2548E-02	-4.0523E-01	-2.1425E-01	1.9344E-01	0.0000E+00	0.0000E+00
Surface #	241	242	251	252	261	262
K	-8.7283E+00	-1.8511E+00	-2.8406E+01	-7.3593E+00	0.0000E+00	0.0000E+00
a_4	1.3269E-02	1.9728E-01	-2.1987E-01	-1.9625E-01	-2.1098E-01	-1.3502E-01
a_6	3.4034E-01	-9.3793E-02	5.1837E-02	3.9257E-02	2.4728E-02	3.5340E-02
a_8	-2.9497E-01	5.6645E-02	-1.7788E-02	-1.3442E-02	7.5264E-03	-7.5639E-03
a_{10}	2.1211E-01	1.2986E-01	-1.0311E-02	2.3003E-03	-1.3288E-03	4.9863E-04
a_{12}	-2.0645E-01	-1.3411E-01	-4.9013E-03	7.2406E-05	0.0000E+00	0.0000E+00
a_{14}	8.9008E-02	1.1247E-02	1.8012E-04	-1.0985E-04	0.0000E+00	0.0000E+00
a_{16}	-1.3523E-02	1.0187E-02	2.8670E-03	1.0727E-04	0.0000E+00	0.0000E+00

FIG. 13

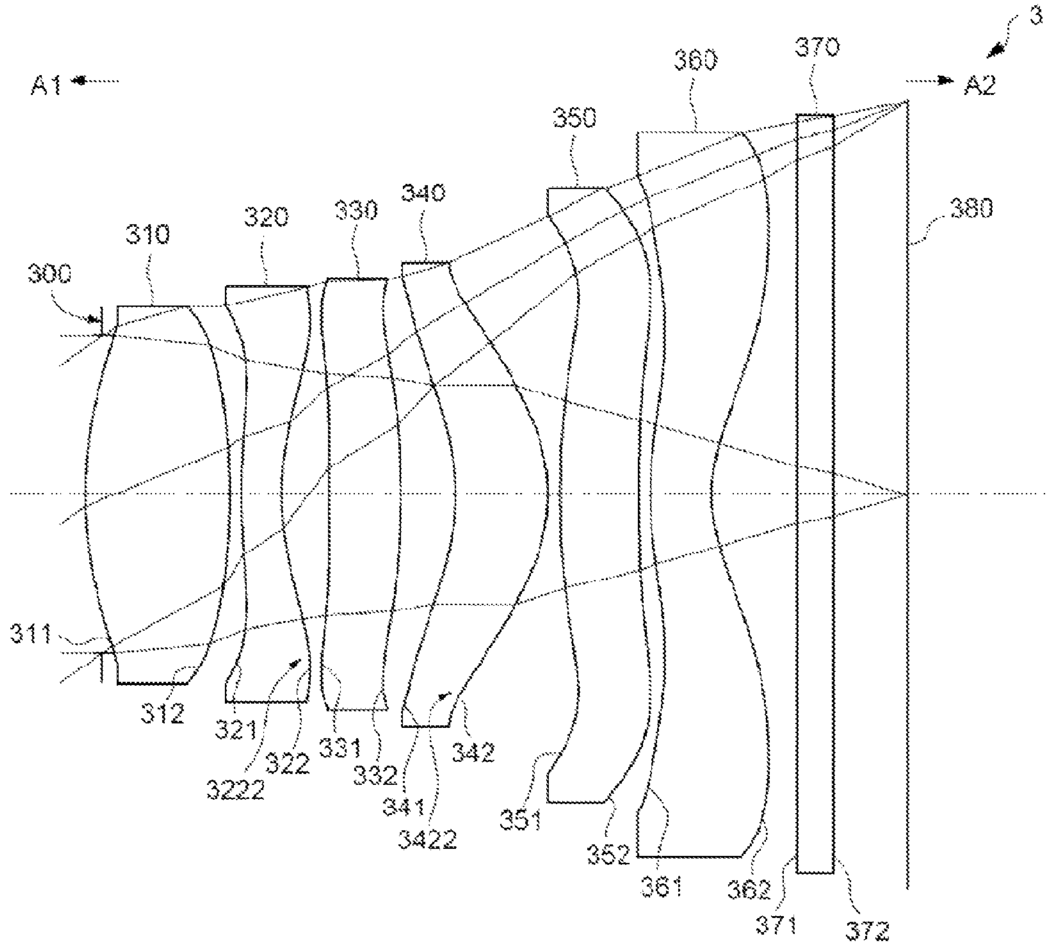

3
A1
A2
300
310
320
330
340
350
360
370
380
311
312
321
322
3222
331
332
341
342
3422
351
352
361
362
371
372

FIG. 14

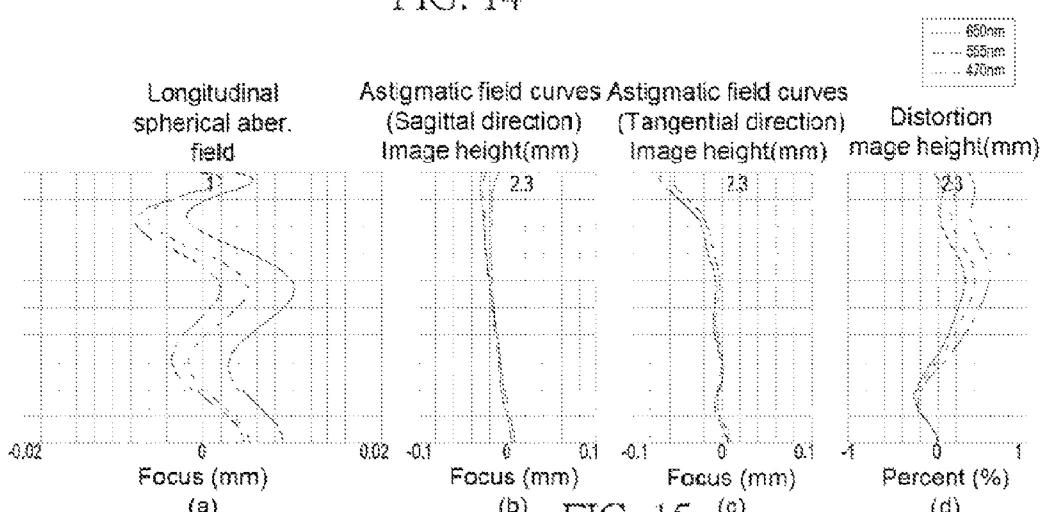

650nm
555nm
470nm
Longitudinal spherical aber.
field
Astigmatic field curves (Sagittal direction)
Image height(mm)
Astigmatic field curves (Tangential direction)
Image height(mm)
Distortion
mage height(mm)
2.3
-0.02
0
0.02
-0.1
0
0.1
-1
1
Focus (mm)
Percent (%)
(a)
(b)
(c)
(d)

FIG. 15

EFL(Effective focus length)= 3.323mm, HFOV(Half angular field of view)= 34.705deg., System length= 4.804mm, Image heigh= 2.3mm, Fno=1.8							
Surface #		Radius	Thickness	Refractive index	Abbe number	Focus	Material
-	Object	∞	∞				
300	Aperture stop	∞	-0.100				
311	1st lens element	2.374	0.844	1.535	55.712	2.783	plastic
312		-3.530	0.070				
321	2nd lens element	3.500	0.230	1.643	22.437	-3.777	plastic
322		1.403	0.282				
331	3rd lens element	32.108	0.415	1.535	55.712	8.912	plastic
332		-5.596	0.320				
341	4th lens element	-1.418	0.544	1.535	55.712	3.596	plastic
342		-0.927	0.069				
351	5th lens element	6.545	0.461	1.535	55.712	26.586	plastic
352		11.792	0.068				
361	6th lens element	2.176	0.359	1.531	55.744	-3.207	plastic
362		0.902	0.500				
371	IR cut filter	∞	0.210	1.517	64.167		plastic
372		∞	0.433				
380	Image plane	∞	0.000				

FIG. 16

Aspherical parameters						
Surface #	311	312	321	322	331	332
K	0.0000E+00	0.0000E+00	0.0000E+00	-8.1004E+00	0.0000E+00	0.0000E+00
a_4	-7.7503E-03	8.0359E-02	-2.0172E-01	-3.3382E-02	-1.4045E-01	-6.3790E-02
a_6	-1.0472E-02	-1.5544E-01	1.6277E-01	2.5459E-02	8.1253E-02	5.7906E-02
a_8	8.6787E-03	5.7540E-02	-2.5650E-01	-8.5209E-02	0.0000E+00	0.0000E+00
a_{10}	-2.3725E-02	-1.4586E-02	1.0973E-01	3.4918E-02	0.0000E+00	0.0000E+00
a_{12}	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
a_{14}	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
a_{16}	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Surface #	341	342	351	352	361	362
K	0.0000E+00	-7.9873E-01	1.2549E+01	-2.0195E+03	0.0000E+00	-3.4874E+00
a_4	1.5527E-01	2.9126E-01	8.8809E-02	9.7974E-02	-2.1656E-01	-1.6129E-01
a_6	2.6066E-02	-2.8883E-01	-9.3959E-02	-6.5764E-02	6.4828E-02	1.0104E-01
a_8	-9.0308E-03	2.8720E-01	8.8882E-03	8.7463E-03	-8.4513E-03	-5.2492E-02
a_{10}	2.4332E-03	-1.8580E-01	2.6723E-02	0.0000E+00	0.0000E+00	1.9591E-02
a_{12}	0.0000E+00	7.1964E-02	-2.4548E-02	0.0000E+00	0.0000E+00	-4.4893E-03
a_{14}	0.0000E+00	-1.1242E-02	8.6720E-03	0.0000E+00	0.0000E+00	5.4863E-04
a_{16}	0.0000E+00	0.0000E+00	-1.0785E-03	0.0000E+00	0.0000E+00	-2.7640E-05

FIG. 17

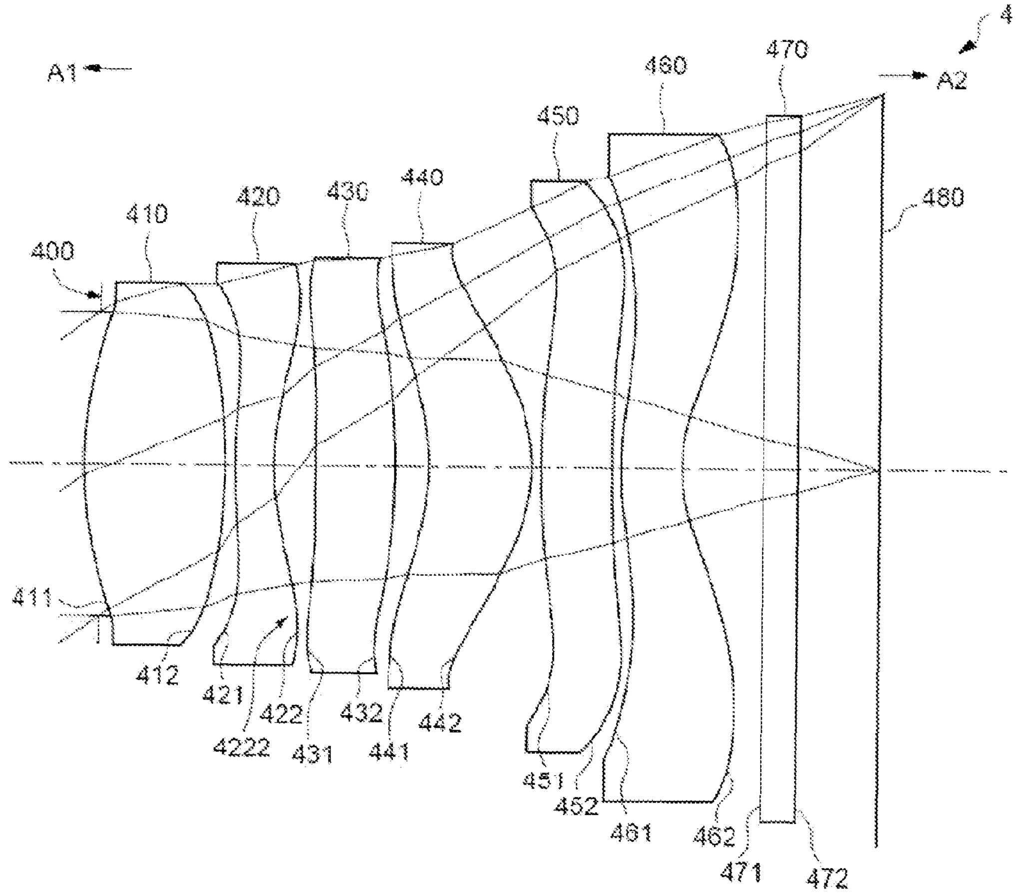

4
A1
A2
400
410
420
430
440
450
460
470
480
411
412
421
422
4222
431
432
441
442
451
452
461
462
471
472

FIG. 18

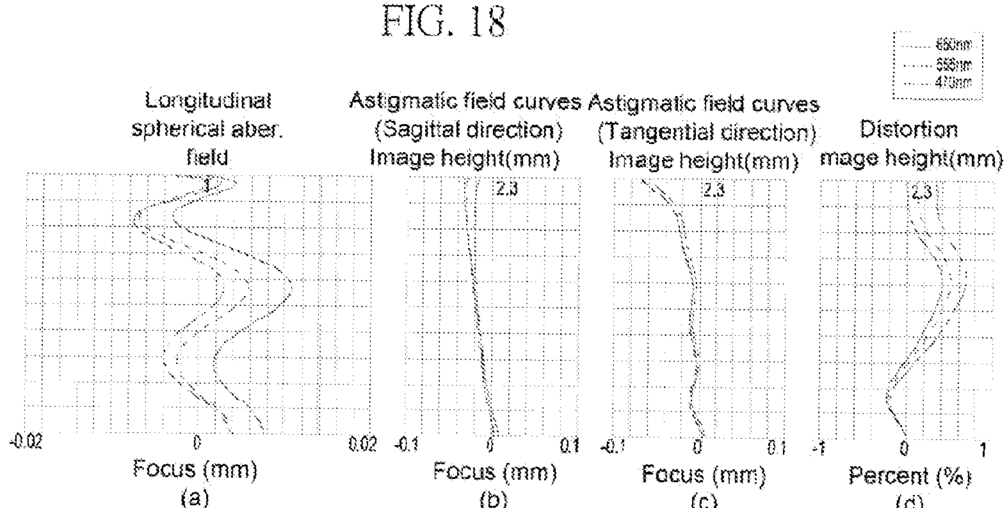

650nm
555nm
470nm
Longitudinal spherical aber. field
Astigmatic field curves (Sagittal direction) Image height(mm)
Astigmatic field curves (Tangential direction) Image height(mm)
Distortion Image height(mm)
1
2.3
2.3
2.3
-0.02
0
0.02
-0.1
0
0.1
-0.1
0
0.1
-1
0
1
Focus (mm)
(a)
Focus (mm)
(b)
Focus (mm)
(c)
Percent (%)
(d)

FIG. 19

EFL(Effective focus length)= 3.342mm, HFOV(Half angular field of view)= 34.537deg., System length=4.869mm, Image heigh= 2.3mm, Fno=1.8							
Surface #		Radius	Thickness	Refractive index	Abbe number	Focus	Material
-	Object	∞	∞				
400	Aperture stop	∞	-0.100				
411	1st lens element	2.383	0.862	1.535	55.712	2.773	plastic
412		-3.466	0.066				
421	2nd lens element	3.887	0.232	1.643	22.437	-3.795	plastic
422		1.471	0.258				
431	3rd lens element	21.775	0.489	1.535	55.712	7.560	plastic
432		-4.948	0.205				
441	4th lens element	-1.477	0.631	1.535	55.712	3.644	plastic
442		-0.967	0.057				
451	5th lens element	7.815	0.435	1.535	55.712	35.571	plastic
452		12.972	0.053				
461	6th lens element	2.128	0.373	1.531	55.744	-3.188	plastic
462		0.887	0.500				
471	IR cut filter	∞	0.210	1.517	64.167		plastic
472		∞	0.499				
480	Image plane	∞	0.000				

FIG. 20

Aspherical parameters						
Surface #	411	412	421	422	431	432
K	0.0000E+00	0.0000E+00	0.0000E+00	-9.1195E+00	0.0000E+00	0.0000E+00
a_4	-8.2118E-03	7.5897E-02	-1.9970E-01	-3.4398E-02	-1.4583E-01	-6.4781E-02
a_6	-9.0759E-03	-1.5380E-01	1.6128E-01	2.6155E-02	7.9589E-02	5.5227E-02
a_8	8.1481E-03	5.8264E-02	-2.5767E-01	-8.4948E-02	0.0000E+00	0.0000E+00
a_{10}	-2.3586E-02	-1.5238E-02	1.0868E-01	3.4365E-02	0.0000E+00	0.0000E+00
a_{12}	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
a_{14}	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
a_{16}	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Surface #	441	442	451	452	461	462
K	0.0000E+00	-8.0587E-01	1.3276E+01	-2.3684E+03	0.0000E+00	-3.4768E+00
a_4	1.6064E-01	2.9554E-01	8.7702E-02	9.6984E-02	-2.2097E-01	-1.6257E-01
a_6	2.8465E-02	-2.9018E-01	-9.3086E-02	-6.6182E-02	6.3642E-02	1.0072E-01
a_8	-9.9914E-03	2.8766E-01	8.6100E-03	8.8004E-03	-8.4843E-03	-5.2504E-02
a_{10}	1.4359E-03	-1.8529E-01	2.6731E-02	0.0000E+00	0.0000E+00	1.9596E-02
a_{12}	0.0000E+00	7.2073E-02	-2.4496E-02	0.0000E+00	0.0000E+00	-4.4889E-03
a_{14}	0.0000E+00	-1.1332E-02	8.6958E-03	0.0000E+00	0.0000E+00	5.4877E-04
a_{16}	0.0000E+00	0.0000E+00	-1.0722E-03	0.0000E+00	0.0000E+00	-2.7525E-05

FIG. 21

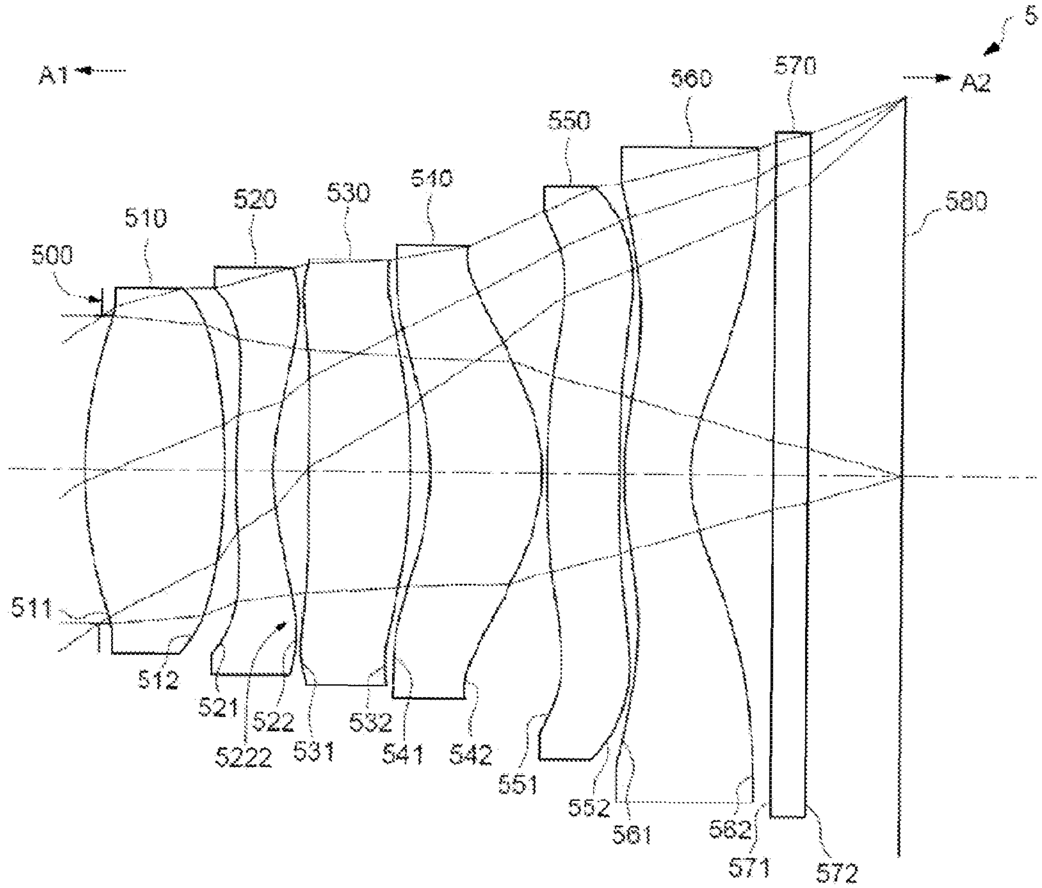

5
A1
A2
500
510
520
530
540
550
560
570
580
511
512
521
522
5222
531
532
541
542
551
552
561
562
571
572

FIG. 22

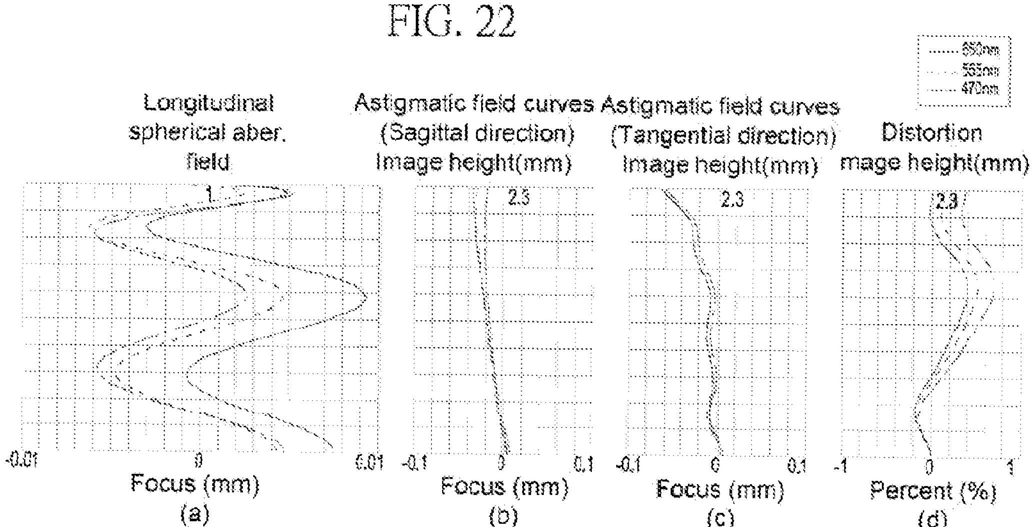

650nm
555nm
470nm
Longitudinal spherical aber.
field
1
-0.01
0
0.01
Focus (mm)
(a)
Astigmatic field curves (Sagittal direction)
Image height(mm)
2.3
-0.1
0
0.1
Focus (mm)
(b)
Astigmatic field curves (Tangential direction)
Image height(mm)
2.3
-0.1
0
0.1
Focus (mm)
(c)
Distortion
mage height(mm)
2.3
-1
0
1
Percent (%)
(d)

FIG. 23

EFL(Effective focus length)= 3.344mm, HFOV(Half angular field of view)= 34.520deg., System length=4.955mm, Image heigh= 2.3mm, Fno=1.8							
Surface #		Radius	Thickness	Refractive index	Abbe number	Focus	Material
-	Object	∞	∞				
500	Aperture stop	∞	-0.100				
511	1st lens element	2.425	0.846	1.535	55.712	2.875	plastic
512		-3.726	0.072				
521	2nd lens element	4.106	0.225	1.643	22.437	-3.810	plastic
522		1.508	0.211				
531	3rd lens element	12.791	0.619	1.535	55.712	6.098	plastic
532		-4.325	0.121				
541	4th lens element	-1.492	0.677	1.535	55.712	3.821	plastic
542		-1.001	0.030				
551	5th lens element	7.351	0.440	1.535	55.712	31.584	plastic
552		12.705	0.028				
561	6th lens element	2.061	0.399	1.531	55.744	-3.136	plastic
562		0.861	0.500				
571	IR cut filter	∞	0.210	1.517	64.167		plastic
572		∞	0.576				
580	Image plane	∞	0.000				

FIG. 24

Aspherical parameters						
Surface #	511	512	521	522	531	532
K	0.0000E+00	0.0000E+00	0.0000E+00	-9.8631E+00	0.0000E+00	0.0000E+00
a_4	-1.0333E-02	6.2392E-02	-1.9858E-01	-3.2928E-02	-1.4973E-01	-6.4061E-02
a_6	-9.5936E-03	-1.5107E-01	1.5799E-01	2.6165E-02	7.7214E-02	5.2017E-02
a_8	7.7193E-03	5.8824E-02	-2.5700E-01	-8.5603E-02	0.0000E+00	0.0000E+00
a_{10}	-2.4344E-02	-1.5283E-02	1.0853E-01	3.4005E-02	0.0000E+00	0.0000E+00
a_{12}	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
a_{14}	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
a_{16}	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Surface #	541	542	551	552	561	562
K	0.0000E+00	-8.0976E-01	1.2578E+01	-1.8884E+03	0.0000E+00	-3.4362E+00
a_4	1.6188E-01	3.0011E-01	8.9593E-02	1.0112E-01	-2.2524E-01	-1.5608E-01
a_6	3.1243E-02	-2.9294E-01	-9.2544E-02	-6.7076E-02	6.3762E-02	1.0064E-01
a_8	-9.8417E-03	2.8680E-01	8.5362E-03	8.7368E-03	-8.1578E-03	-5.2451E-02
a_{10}	3.7765E-04	-1.8530E-01	2.6790E-02	0.0000E+00	0.0000E+00	1.9617E-02
a_{12}	0.0000E+00	7.2119E-02	-2.4461E-02	0.0000E+00	0.0000E+00	-4.4853E-03
a_{14}	0.0000E+00	-1.1344E-02	8.6991E-03	0.0000E+00	0.0000E+00	5.4897E-04
a_{16}	0.0000E+00	0.0000E+00	-1.0779E-03	0.0000E+00	0.0000E+00	-2.7572E-05

FIG. 25

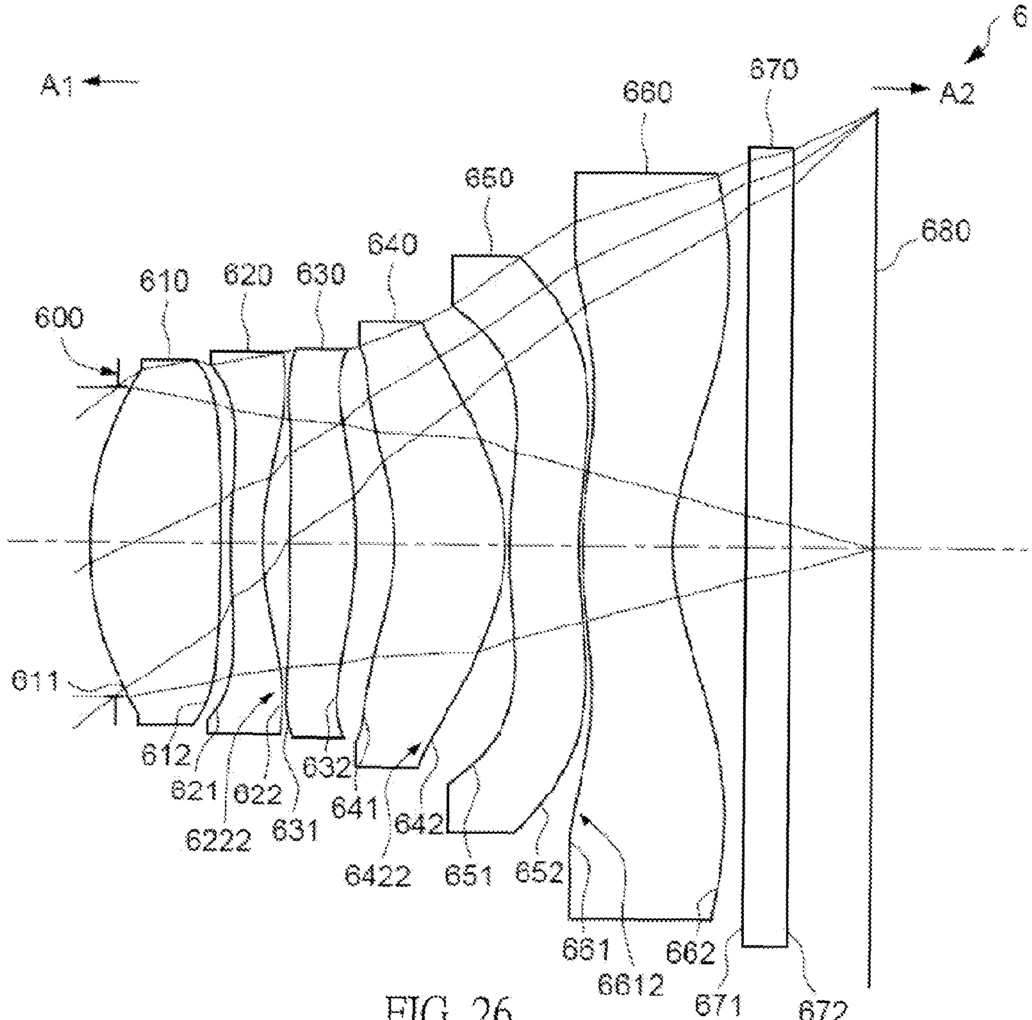

6
A1
A2
600
610
620
630
640
650
660
670
680
611
612
621
622
6222
631
632
641
642
6422
651
652
661
6612
662
671
672

FIG. 26

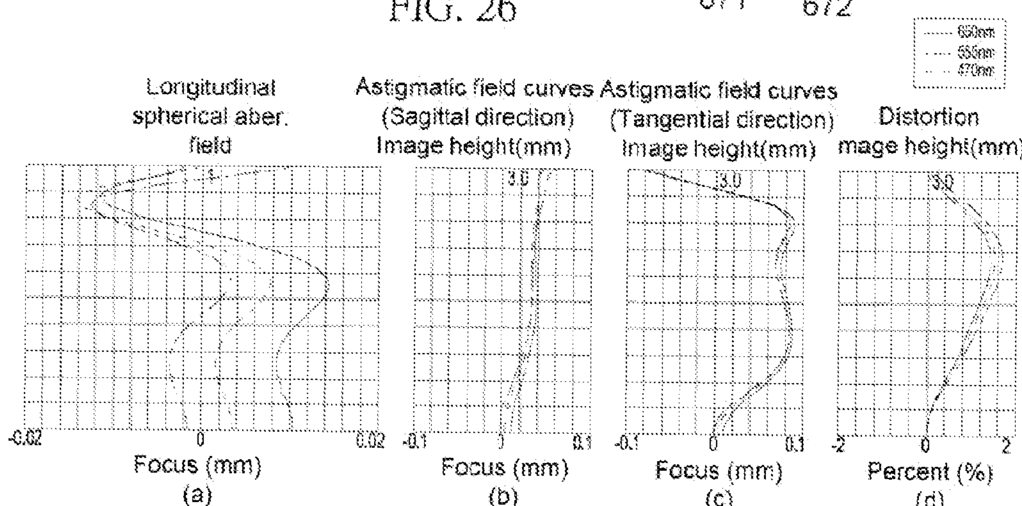

650nm
555nm
470nm
Longitudinal spherical aber. field
Astigmatic field curves (Sagittal direction) Image height(mm)
Astigmatic field curves (Tangential direction) Image height(mm)
Distortion Image height(mm)
3.0
-0.02
0
0.02
-0.1
0
0.1
-2
0
2
Focus (mm)
Percent (%)
(a)
(b)
(c)
(d)

FIG. 27

EFL(Effective focus length)= 3.824mm, HFOV(Half angular field of view)= 38.122deg., System length5.384mm, Image heigh= 3.0mm, Fno=1.8							
Surface #		Radius	Thickness	Refractive index	Abbe number	Focus	Material
-	Object	∞	∞				
600	Aperture stop	∞	-0.180				
611	1st lens element	2.207	0.899	1.535	55.712	3.639	plastic
612		-14.576	0.074				
621	2nd lens element	4.500	0.217	1.643	22.437	-5.030	plastic
622		1.854	0.188				
631	3rd lens element	15.170	0.452	1.535	55.712	4.853	plastic
632		-3.113	0.268				
641	4th lens element	-1.502	0.761	1.535	55.712	7.554	plastic
642		-1.290	0.029				
651	5th lens element	3.608	0.472	1.535	55.712	-30.061	plastic
652		2.814	0.030				
661	6th lens element	3.178	0.622	1.531	55.744	-6.061	plastic
662		1.493	0.500				
671	IR cut filter	∞	0.300	1.517	64.167		plastic
672		∞	0.572				
680	Image plane	∞	0.000				

FIG. 28

Aspherical parameters						
Surface #	611	612	621	622	631	632
K	0.0000E+00	0.0000E+00	0.0000E+00	-6.4044E+00	0.0000E+00	0.0000E+00
a_4	2.1659E-02	2.8416E-02	-1.6903E-01	-1.0546E-01	-9.8341E-02	1.7144E-02
a_6	-3.4043E-02	-4.4848E-02	1.3960E-01	1.0906E-01	5.0436E-02	3.1696E-02
a_8	2.8516E-02	-1.6234E-04	-1.4913E-01	-9.7535E-02	0.0000E+00	0.0000E+00
a_{10}	-1.1739E-02	-2.6681E-03	4.5126E-02	2.8084E-02	0.0000E+00	0.0000E+00
a_{12}	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
a_{14}	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
a_{16}	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
Surface #	641	642	651	652	661	662
K	0.0000E+00	-7.0769E-01	1.5356E-01	-2.6088E+01	0.0000E+00	-4.1959E+00
a_4	2.5402E-01	1.6121E-01	-1.2307E-01	-6.1437E-02	-1.0797E-01	-5.8098E-02
a_6	-6.9644E-02	-1.1919E-01	1.5773E-02	2.9686E-03	1.9669E-02	2.2793E-02
a_8	2.0893E-02	8.5613E-02	-4.0118E-03	2.1536E-04	-1.1997E-03	-7.4098E-03
a_{10}	-3.1458E-03	-3.7251E-02	1.3517E-03	0.0000E+00	0.0000E+00	1.6450E-03
a_{12}	0.0000E+00	7.7715E-03	-1.8686E-03	0.0000E+00	0.0000E+00	-2.3699E-04
a_{14}	0.0000E+00	-3.5865E-04	5.2385E-04	0.0000E+00	0.0000E+00	1.9866E-05
a_{16}	0.0000E+00	0.0000E+00	-9.0792E-06	0.0000E+00	0.0000E+00	-7.1436E-07

FIG. 29

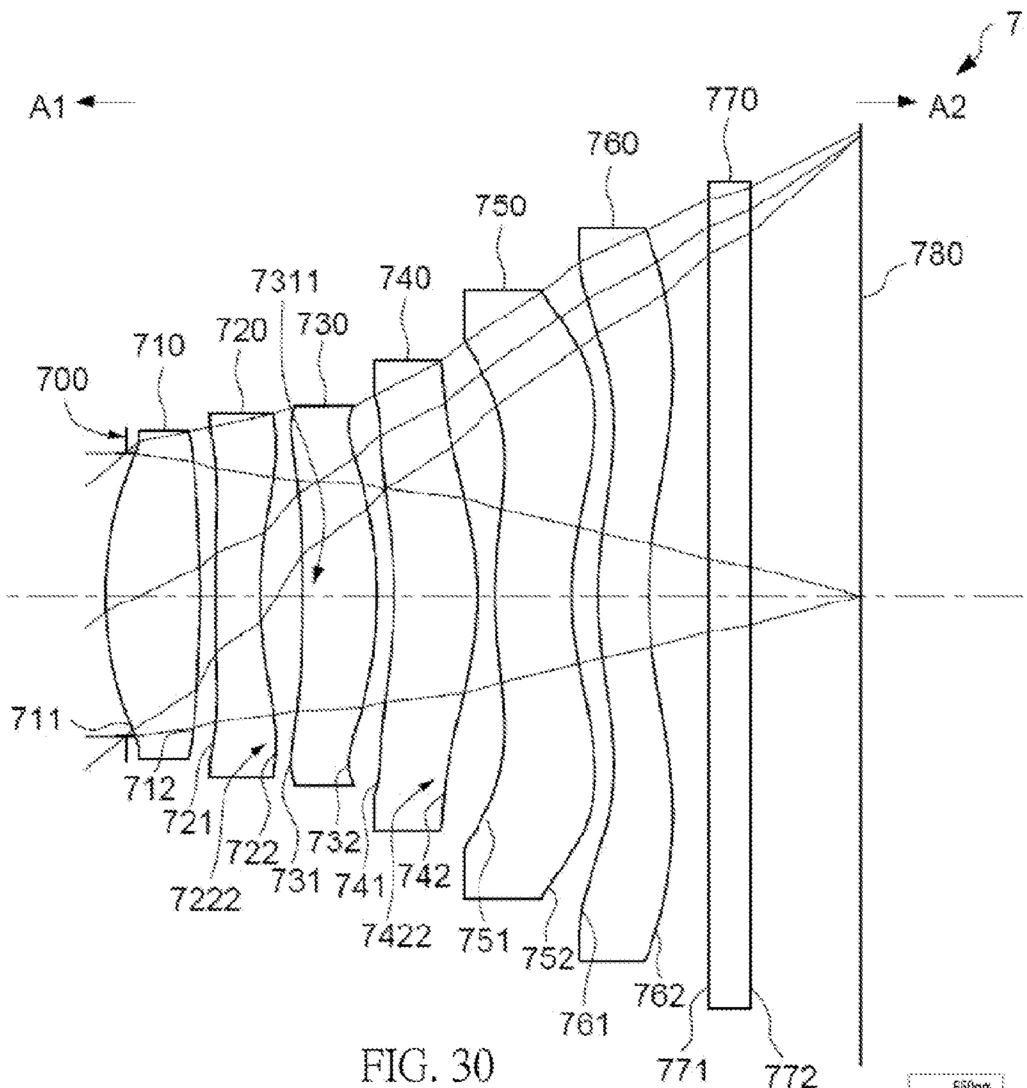

7
A1
A2
770
760
750
780
7311
740
730
720
710
700
711
712
721
722
7222
731
732
741
742
7422
751
752
761
762
771
772

FIG. 30

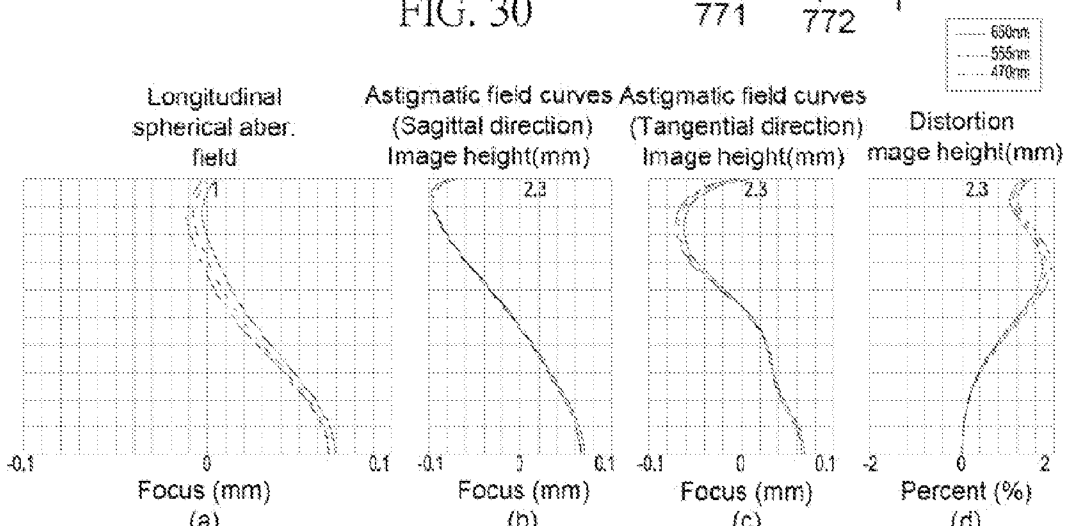

650nm
555nm
470nm
Longitudinal spherical aber. field
Astigmatic field curves (Sagittal direction) Image height(mm)
Astigmatic field curves (Tangential direction) Image height(mm)
Distortion Image height(mm)
1
2.3
2.3
2.3
-0.1
0
0.1
-0.1
0.1
-0.1
0
0.1
-2
0
2
Focus (mm)
(a)
Focus (mm)
(b)
Focus (mm)
(c)
Percent (%)
(d)

FIG. 31

EFL(Effective focus length)= 2.820mm, HFOV(Half angular field of view)= 39.478deg., System length=3.782mm, Image heigh= 2.3mm, Fno=2.0							
Surface #		Radius	Thickness	Refractive index	Abbe number	Focus	Material
-	Object	∞	∞				
700	Aperture stop	∞	-0.100				
711	1st lens element	1.694	0.474	1.535	55.712	2.451	plastic
712		-5.309	0.075				
721	2nd lens element	12.406	0.227	1.643	22.437	-3.746	plastic
722		2.016	0.210				
731	3rd lens element	-10.919	0.374	1.535	55.712	5.246	plastic
732		-2.265	0.085				
741	4th lens element	-2.313	0.413	1.535	55.712	9.652	plastic
742		-1.699	0.092				
751	5th lens element	2.344	0.384	1.535	55.712	-9.401	plastic
752		1.509	0.134				
761	6th lens element	2.139	0.251	1.531	55.744	-758.226	plastic
762		2.041	0.300				
771	IR cut filter	∞	0.210	1.517	64.167		plastic
772		∞	0.554				
780	Image plane	∞	0.000				

FIG. 32

Aspherical parameters						
Surface #	711	712	721	722	731	732
K	-1.3871E+01	-1.4310E+02	0.0000E+00	-3.0746E+01	0.0000E+00	0.0000E+00
a_4	3.1118E-01	5.5507E-02	2.1798E-02	2.2003E-01	-1.0879E-01	-9.0566E-02
a_6	-4.0253E-01	-1.5253E-01	-3.0351E-01	-6.2562E-01	-2.9642E-02	6.1544E-02
a_8	3.5798E-01	-1.9279E-01	-8.6834E-02	3.0691E-01	1.3337E-01	1.5105E-01
a_{10}	-2.0928E-01	2.1912E-01	2.7968E-01	1.1342E-01	5.1687E-02	4.0761E-02
a_{12}	8.7247E-02	4.1232E-01	4.0190E-01	-1.1748E-01	0.0000E+00	0.0000E+00
a_{14}	-3.9397E-01	4.6021E-02	-1.4574E-01	-2.0541E-01	0.0000E+00	0.0000E+00
a_{16}	4.0167E-01	-6.9884E-01	-3.8180E-01	2.6871E-01	0.0000E+00	0.0000E+00
Surface #	741	742	751	752	761	762
K	-3.6793E+01	-1.6432E+00	-6.7163E+00	-5.4174E+00	0.0000E+00	0.0000E+00
a_4	-5.8540E-02	1.5439E-01	-2.2615E-01	-1.5487E-01	-2.1223E-01	-1.8625E-01
a_6	2.9137E-01	-1.1555E-01	4.7016E-02	2.9415E-02	2.5388E-02	4.7726E-02
a_8	-3.0447E-01	5.6267E-02	-1.4557E-02	-1.2761E-02	7.3899E-03	-7.0506E-03
a_{10}	2.3195E-01	1.3077E-01	9.2470E-04	2.2949E-03	-1.4459E-03	6.6228E-05
a_{12}	-1.8665E-01	-1.3351E-01	2.3119E-03	-7.7857E-05	0.0000E+00	0.0000E+00
a_{14}	8.6490E-02	1.2329E-02	8.5650E-04	-1.1768E-04	0.0000E+00	0.0000E+00
a_{16}	-4.5820E-02	1.1775E-02	1.0929E-04	1.4871E-04	0.0000E+00	0.0000E+00

FIG. 33

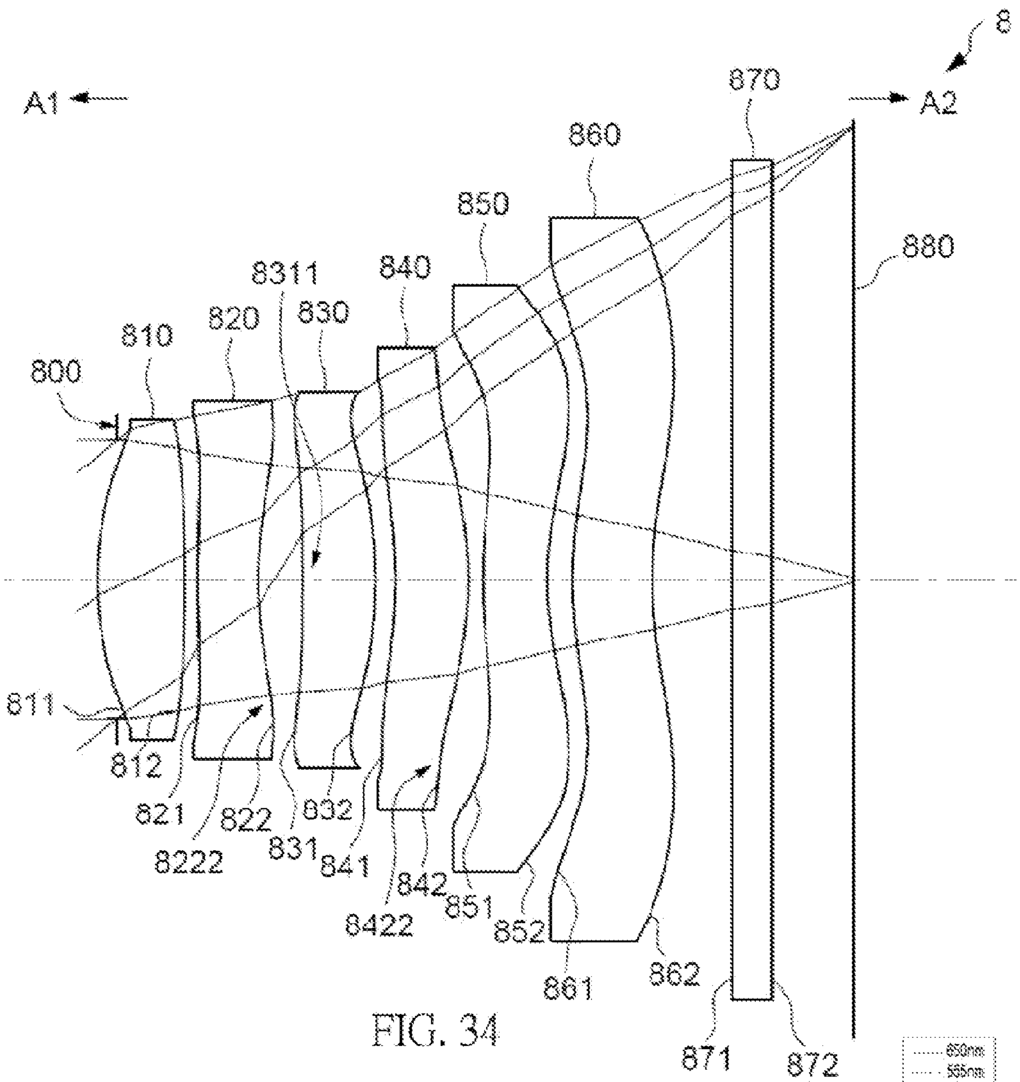

8
A1
A2
870
860
880
850
8311
840
830
820
810
800
811
812
821
822
832
8222
831
841
842
8422
851
852
861
862
871
872

FIG. 34

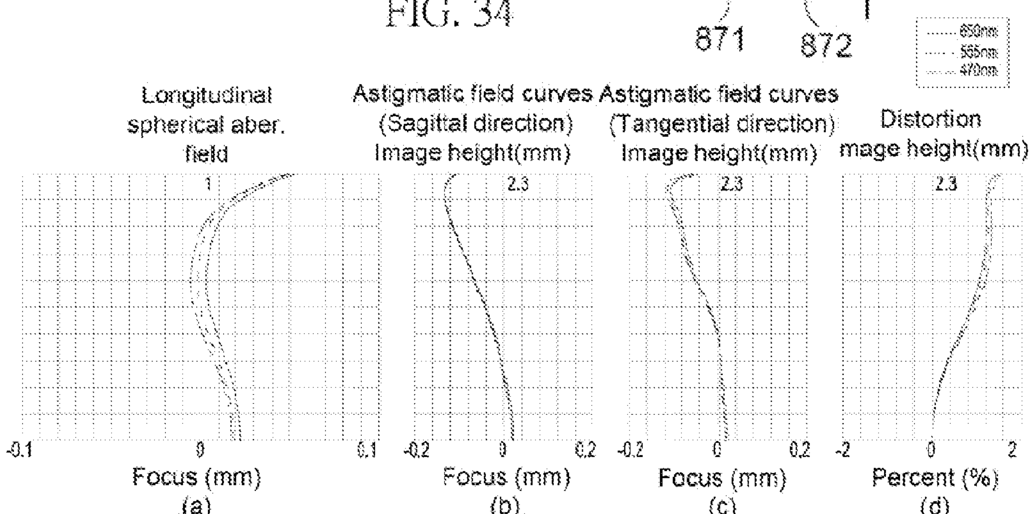

650nm
555nm
470nm
Longitudinal
spherical aber.
field
Astigmatic field curves
(Sagittal direction)
Image height(mm)
Astigmatic field curves
(Tangential direction)
Image height(mm)
Distortion
mage height(mm)
1
2.3
2.3
2.3
-0.1
0
0.1
-0.2
0
0.2
-0.2
0
0.2
-2
0
2
Focus (mm)
(a)
Focus (mm)
(b)
Focus (mm)
(c)
Percent (%)
(d)

FIG. 35

EFL(Effective focus length)= 2.822mm, HFOV(Half angular field of view)= 38.967deg., System length=3.840mm, Image heigh= 2.3mm, Fno=2.0							
Surface #		Radius	Thickness	Refractive index	Abbe number	Focus	Material
-	Object	∞	∞				
800	Aperture stop	∞	-0.100				
811	1st lens element	1.702	0.445	1.535	55.712	2.510	plastic
812		-5.883	0.065				
821	2nd lens element	11.020	0.305	1.643	22.437	-3.872	plastic
822		2.021	0.226				
831	3rd lens element	-25.945	0.367	1.535	55.712	5.198	plastic
832		-2.532	0.103				
841	4th lens element	-2.431	0.372	1.535	55.712	10.705	plastic
842		-1.800	0.071				
851	5th lens element	2.557	0.329	1.535	55.712	-9.244	plastic
852		1.612	0.129				
861	6th lens element	2.185	0.403	1.531	55.744	169.603	plastic
862		2.095	0.400				
871	IR cut filter	∞	0.210	1.517	64.167		plastic
872		∞	0.412				
880	Image plane	∞	0.000				

FIG. 36

Aspherical parameters						
Surface #	811	812	821	822	831	832
K	-1.4374E+01	-1.6113E+02	0.0000E+00	-3.0262E+01	0.0000E+00	0.0000E+00
a_4	3.1178E-01	5.1193E-02	2.3994E-02	2.2247E-01	-1.1107E-01	-8.9072E-02
a_6	-4.0020E-01	-1.5801E-01	-3.0376E-01	-6.2256E-01	-3.2601E-02	6.3817E-02
a_8	3.5975E-01	-1.9730E-01	-8.7914E-02	3.0942E-01	1.3104E-01	1.5344E-01
a_{10}	-2.1291E-01	2.1623E-01	2.7790E-01	1.1520E-01	4.8522E-02	4.3096E-02
a_{12}	7.6652E-02	4.0825E-01	4.0217E-01	-1.1652E-01	0.0000E+00	0.0000E+00
a_{14}	-4.1480E-01	3.5167E-02	-1.4277E-01	-2.0532E-01	0.0000E+00	0.0000E+00
a_{16}	3.6361E-01	-7.2719E-01	-3.6841E-01	2.6788E-01	0.0000E+00	0.0000E+00
Surface #	841	842	851	852	861	862
K	-3.4788E+01	-1.5526E+00	-6.2854E+00	-5.4627E+00	0.0000E+00	0.0000E+00
a_4	-5.1648E-02	1.5309E-01	-2.2522E-01	-1.5383E-01	-2.1240E-01	-1.8783E-01
a_6	2.9039E-01	-1.1544E-01	4.7546E-02	2.9412E-02	2.5438E-02	4.8009E-02
a_8	-3.0212E-01	5.6173E-02	-1.4354E-02	-1.2871E-02	7.4100E-03	-6.9771E-03
a_{10}	2.3557E-01	1.3052E-01	8.9894E-04	2.2548E-03	-1.4395E-03	7.5239E-05
a_{12}	-1.8365E-01	-1.3374E-01	2.2825E-03	-9.0209E-05	0.0000E+00	0.0000E+00
a_{14}	8.9366E-02	1.2202E-02	8.3160E-04	-1.2181E-04	0.0000E+00	0.0000E+00
a_{16}	-4.3181E-02	1.1710E-02	8.5155E-05	1.4715E-04	0.0000E+00	0.0000E+00

FIG. 37

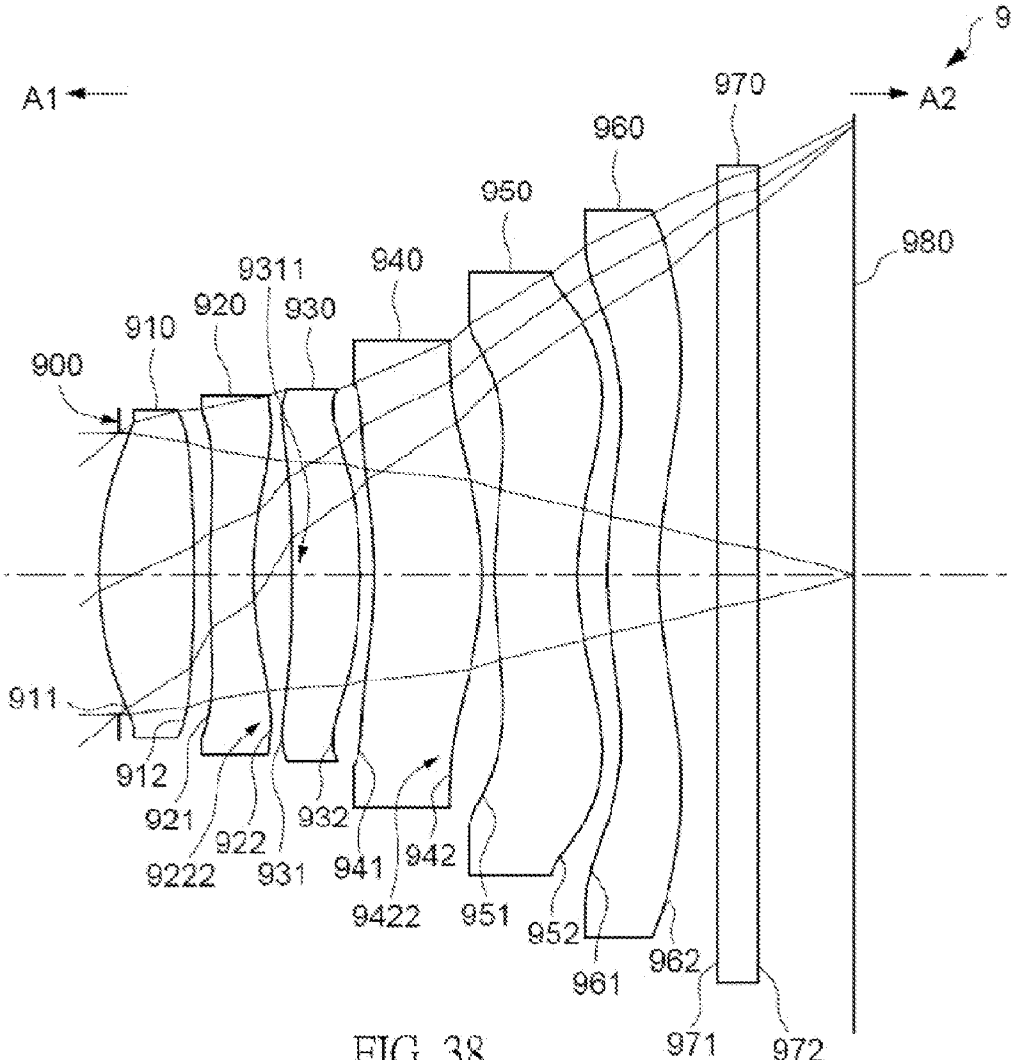

9
A1
A2
970
960
950
980
940
9311
920
930
910
900
911
912
921
9222
922
931
932
941
942
9422
951
952
961
962
971
972

FIG. 38

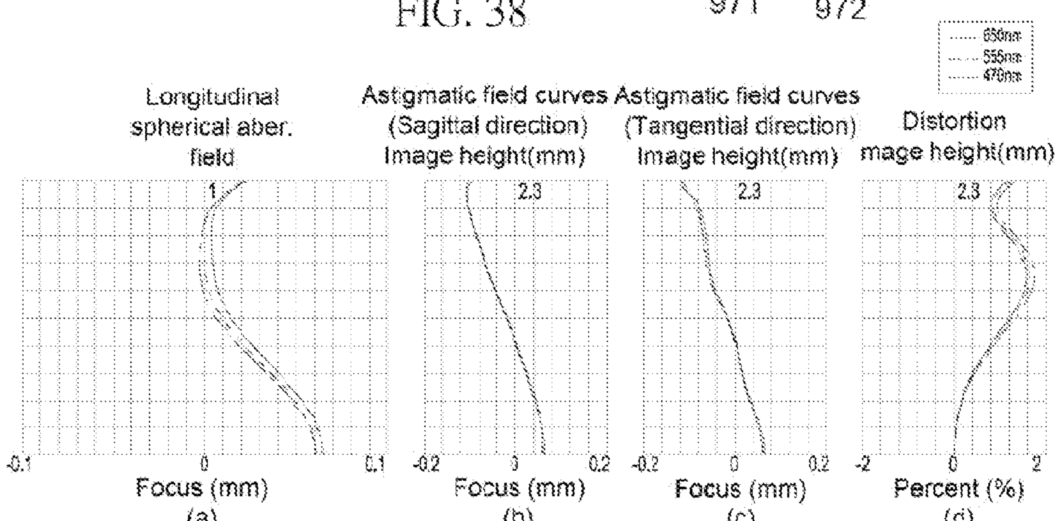

650nm
555nm
470nm
Longitudinal spherical aber.
field
1
-0.1
0
0.1
Focus (mm)
(a)
Astigmatic field curves (Sagittal direction)
Image height(mm)
2.3
-0.2
0
0.2
Focus (mm)
(b)
Astigmatic field curves (Tangential direction)
Image height(mm)
2.3
-0.2
0
0.2
Focus (mm)
(c)
Distortion
mage height(mm)
2.3
-2
0
2
Percent (%)
(d)

FIG. 39

EFL(Effective focus length)= 2.865mm, HFOV(Half angular field of view)= 39.045deg., System length=3.862mm, Image heigh= 2.3mm, Fno=2.0							
Surface #		Radius	Thickness	Refractive index	Abbe number	Focus	Material
-	Object	∞	∞				
900	Aperture stop	∞	-0.100				
911	1st lens element	1.665	0.489	1.535	55.712	2.438	plastic
912		-5.489	0.078				
921	2nd lens element	8.867	0.224	1.643	22.437	-3.797	plastic
922		1.907	0.195				
931	3rd lens element	-13.834	0.352	1.535	55.712	5.269	plastic
932		-2.369	0.070				
941	4th lens element	-2.313	0.552	1.535	55.712	9.243	plastic
942		-1.709	0.064				
951	5th lens element	2.332	0.424	1.535	55.712	-7.907	plastic
952		1.409	0.153				
961	6th lens element	2.169	0.264	1.531	55.744	-684.563	plastic
962		2.065	0.300				
971	IR cut filter	∞	0.210	1.517	64.167		plastic
972		∞	0.487				
980	Image plane	∞	0.000				

FIG. 40

Aspherical parameters						
Surface #	911	912	921	922	931	932
K	-1.3359E+01	-1.3457E+02	0.0000E+00	-2.4495E+01	0.0000E+00	0.0000E+00
a_4	3.1700E-01	5.6710E-02	2.0735E-02	2.3591E-01	-1.1569E-01	-9.4363E-02
a_6	-4.0800E-01	-1.6223E-01	-3.4513E-01	-6.2714E-01	-2.6059E-02	5.3841E-02
a_8	3.5468E-01	-2.2491E-01	-1.0888E-01	2.9297E-01	1.4086E-01	1.4038E-01
a_{10}	-2.4118E-01	1.6663E-01	2.5005E-01	1.0305E-01	4.9636E-02	4.3147E-02
a_{12}	1.7919E-01	3.4478E-01	3.7918E-01	-1.1174E-01	0.0000E+00	0.0000E+00
a_{14}	-3.9648E-01	2.2100E-02	-1.6983E-01	-1.9512E-01	0.0000E+00	0.0000E+00
a_{16}	1.3980E-01	-6.5163E-01	-3.3305E-01	2.5100E-01	0.0000E+00	0.0000E+00
Surface #	941	942	951	952	961	962
K	-4.0406E+01	-1.5709E+00	-6.1609E+00	-5.1696E+00	0.0000E+00	0.0000E+00
a_4	-5.0883E-02	1.5441E-01	-2.2487E-01	-1.5312E-01	-2.1176E-01	-1.8577E-01
a_6	2.8907E-01	-1.1503E-01	4.8096E-02	2.9689E-02	2.5291E-02	4.8049E-02
a_8	-3.0868E-01	5.7037E-02	-1.4122E-02	-1.2948E-02	7.3909E-03	-7.0185E-03
a_{10}	2.2771E-01	1.3182E-01	1.0673E-03	2.2973E-03	-1.4320E-03	7.4530E-05
a_{12}	-1.9070E-01	-1.3310E-01	2.1680E-03	-8.8955E-05	0.0000E+00	0.0000E+00
a_{14}	7.7417E-02	1.2593E-02	8.9791E-04	-1.1977E-04	0.0000E+00	0.0000E+00
a_{16}	-5.5655E-02	1.1835E-02	1.6783E-04	1.4347E-04	0.0000E+00	0.0000E+00

FIG. 41

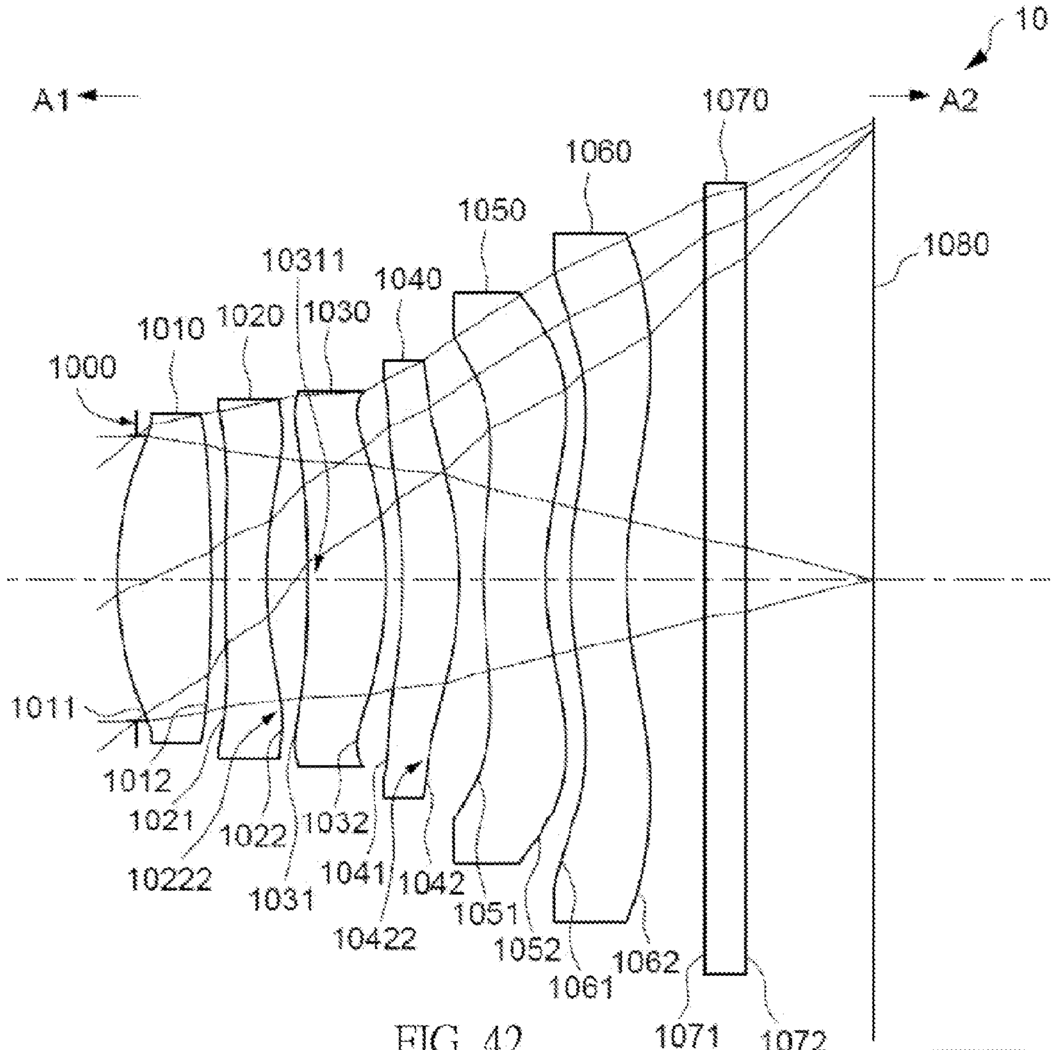

10
A1
A2
1070
1060
1080
1050
10311
1040
1020
1030
1010
1000
1011
1012
1021
1022
1032
10222
1031
1041
1042
10422
1051
1052
1061
1062
1071
1072

FIG. 42

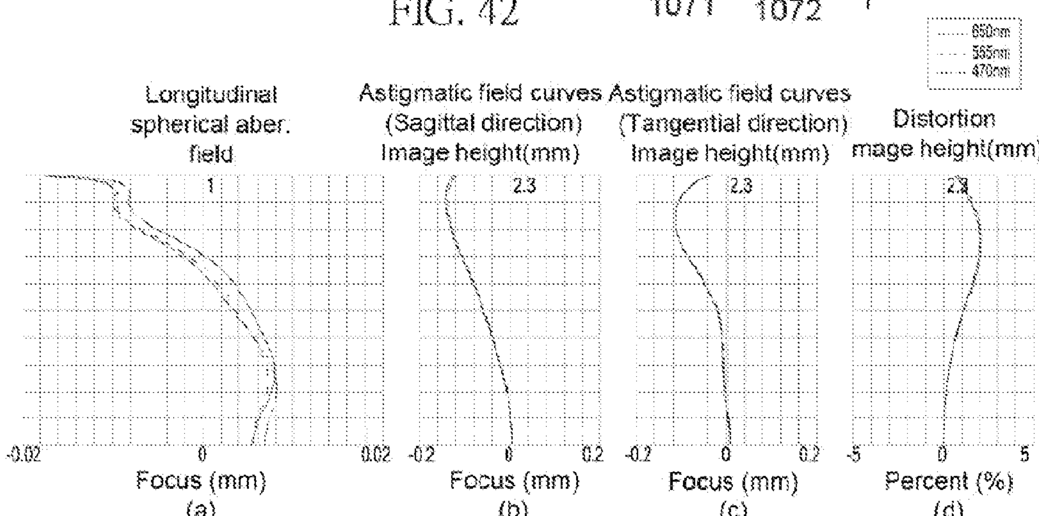

650nm
555nm
470nm
Longitudinal spherical aber.
field
1
-0.02
0
0.02
Focus (mm)
(a)
Astigmatic field curves
(Sagittal direction)
Image height(mm)
2.3
-0.2
0
0.2
Focus (mm)
(b)
Astigmatic field curves
(Tangential direction)
Image height(mm)
2.3
-0.2
0
0.2
Focus (mm)
(c)
Distortion
mage height(mm)
2.3
-5
0
5
Percent (%)
(d)

FIG. 43

EFL(Effective focus length)= 2.897mm, HFOV(Half angular field of view)= 38.311deg., System length=3.866mm, Image heigh= 2.3mm, Fno=2.0							
Surface #		Radius	Thickness	Refractive index	Abbe number	Focus	Material
-	Object	∞	∞				
1000	Aperture stop	∞	-0.100				
1011	1st lens element	1.674	0.484	1.535	55.712	2.471	plastic
1012		-5.749	0.069				
1021	2nd lens element	15.002	0.212	1.643	22.437	-3.578	plastic
1022		1.997	0.207				
1031	3rd lens element	-9.024	0.401	1.535	55.712	5.302	plastic
1032		-2.197	0.086				
1041	4th lens element	-2.333	0.289	1.535	55.712	10.312	plastic
1042		-1.712	0.121				
1051	5th lens element	2.512	0.321	1.535	55.712	-10.710	plastic
1052		1.670	0.127				
1061	6th lens element	2.141	0.286	1.531	55.744	741.086	plastic
1062		2.053	0.400				
1071	IR cut filter	∞	0.210	1.517	64.167		plastic
1072		∞	0.652				
1080	Image plane	∞	0.000				

FIG. 44

Aspherical parameters						
Surface #	1011	1012	1021	1022	1031	1032
K	-1.4476E+01	-1.9631E+02	0.0000E+00	-3.0361E+01	0.0000E+00	0.0000E+00
a_4	3.0921E-01	5.4882E-02	2.4408E-02	2.1777E-01	-1.0924E-01	-9.3479E-02
a_6	-4.0393E-01	-1.5329E-01	-3.0061E-01	-6.2696E-01	-3.0574E-02	6.1018E-02
a_8	3.5716E-01	-1.9250E-01	-8.4585E-02	3.0650E-01	1.3195E-01	1.5193E-01
a_{10}	-2.0935E-01	2.2021E-01	2.8132E-01	1.1362E-01	4.9922E-02	4.2390E-02
a_{12}	8.8170E-02	4.1392E-01	4.0311E-01	-1.1678E-01	0.0000E+00	0.0000E+00
a_{14}	-3.9197E-01	4.7874E-02	-1.4499E-01	-2.0420E-01	0.0000E+00	0.0000E+00
a_{16}	4.0432E-01	-6.9652E-01	-3.8177E-01	2.7049E-01	0.0000E+00	0.0000E+00
Surface #	1041	1042	1051	1052	1061	1062
K	-3.0623E+01	-1.4733E+00	-6.3593E+00	-5.7294E+00	0.0000E+00	0.0000E+00
a_4	-5.7681E-02	1.5166E-01	-2.2760E-01	-1.5459E-01	-2.1249E-01	-1.8500E-01
a_6	2.8720E-01	-1.1665E-01	4.5792E-02	2.9508E-02	2.5414E-02	4.7701E-02
a_8	-3.0499E-01	5.5477E-02	-1.5014E-02	-1.2765E-02	7.4155E-03	-7.1121E-03
a_{10}	2.3494E-01	1.3019E-01	8.0701E-04	2.3029E-03	-1.4358E-03	4.3353E-05
a_{12}	-1.8217E-01	-1.3385E-01	2.3092E-03	-6.8778E-05	0.0000E+00	0.0000E+00
a_{14}	9.1210E-02	1.2201E-02	8.6410E-04	-1.1074E-04	0.0000E+00	0.0000E+00
a_{16}	-4.1484E-02	1.1797E-02	1.0361E-04	1.5328E-04	0.0000E+00	0.0000E+00

FIG. 45

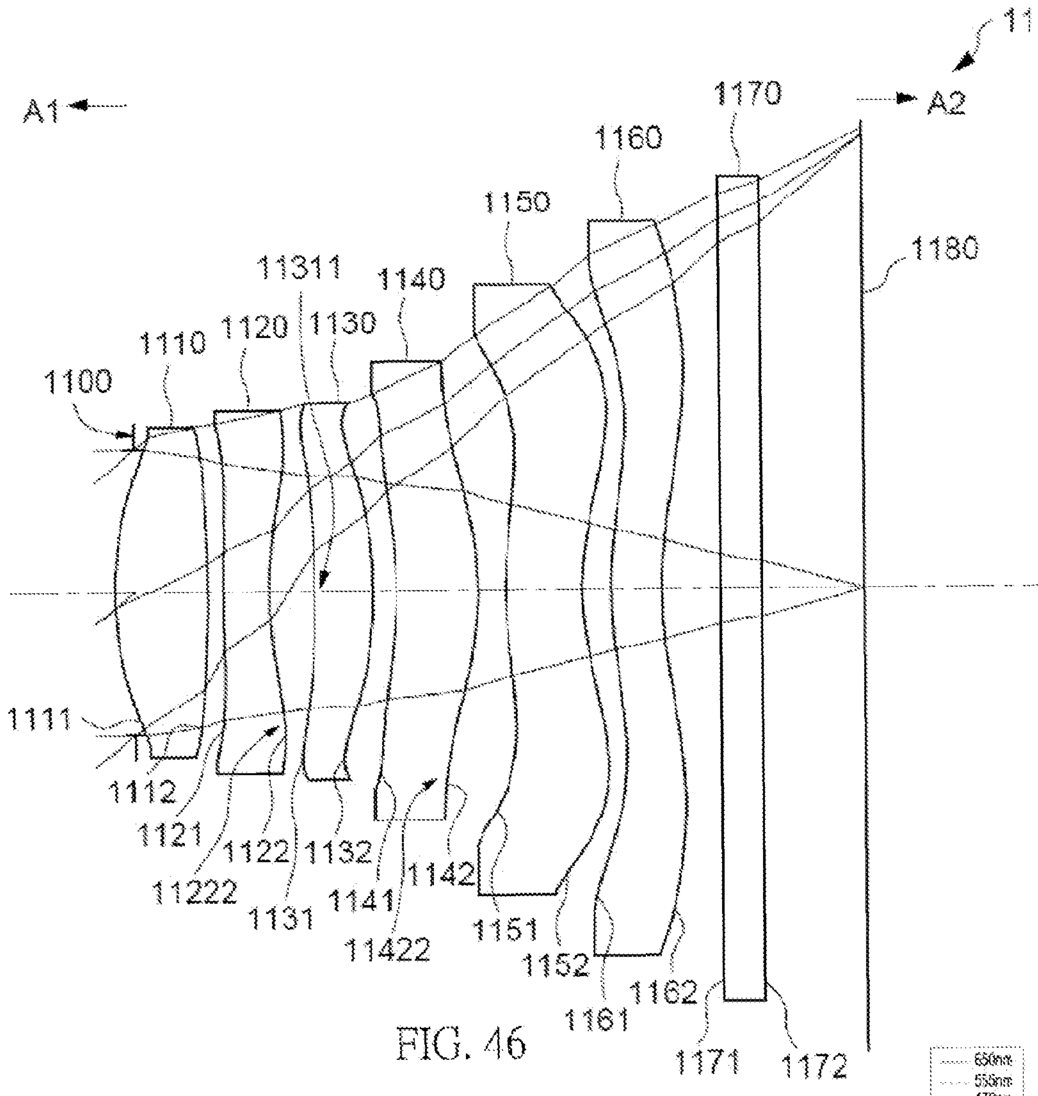

11
A1
A2
1170
1160
1150
1180
11311
1140
1120
1130
1110
1100
1111
1112
1121
1122
1132
11222
1131
1141
1142
11422
1151
1152
1162
1161
1171
1172

FIG. 46

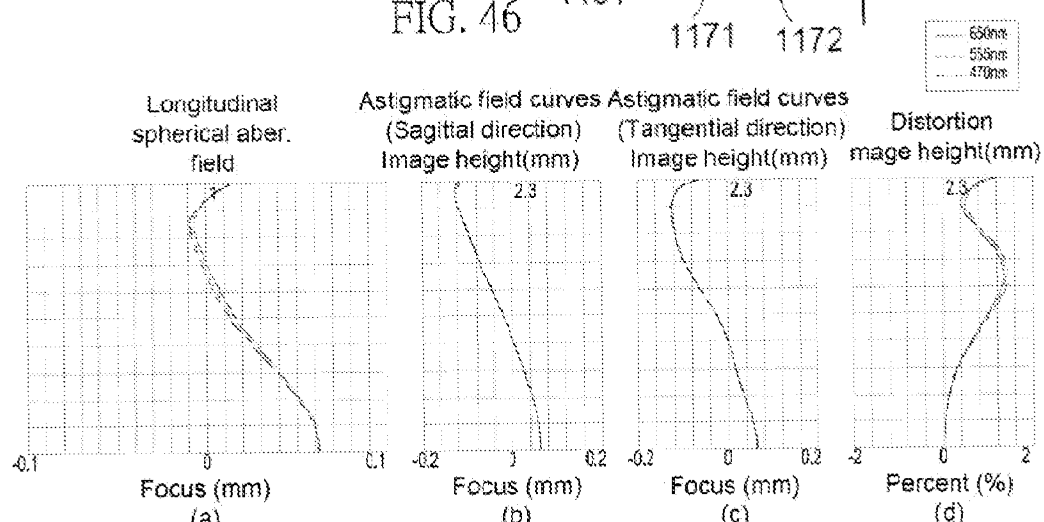

650nm
555nm
470nm
Longitudinal spherical aber.
field
Astigmatic field curves (Sagittal direction)
Image height(mm)
Astigmatic field curves (Tangential direction)
Image height(mm)
Distortion
Image height(mm)
2.3
2.3
2.3
-0.1
0
0.1
-0.2
0
0.2
-0.2
0
0.2
-2
0
2
Focus (mm)
(a)
Focus (mm)
(b)
Focus (mm)
(c)
Percent (%)
(d)

FIG. 47

EFL(Effective focus length)= 2.883mm, HFOV(Half angular field of view)= 38.916deg., System length=3.800mm, Image heigh= 2.3mm, Fno=2.0							
Surface #		Radius	Thickness	Refractive index	Abbe number	Focus	Material
-	Object	∞	∞				
1100	Aperture stop	∞	-0.100				
1111	1st lens element	1.718	0.472	1.535	55.712	2.459	plastic
1112		-5.150	0.077				
1121	2nd lens element	13.930	0.233	1.643	22.437	-3.736	plastic
1122		2.049	0.230				
1131	3rd lens element	-7.816	0.297	1.535	55.712	5.408	plastic
1132		-2.145	0.115				
1141	4th lens element	-2.236	0.412	1.535	55.712	9.222	plastic
1142		-1.639	0.142				
1151	5th lens element	2.233	0.387	1.535	55.712	-8.126	plastic
1152		1.388	0.147				
1161	6th lens element	2.146	0.256	1.531	55.744	-2113.673	plastic
1162		2.054	0.300				
1171	IR cut filter	∞	0.210	1.517	64.167		plastic
1172		∞	0.521				
1180	Image plane	∞	0.000				

FIG. 48

Aspherical parameters						
Surface #	1111	1112	1121	1122	1131	1132
K	-1.4608E+01	-1.2968E+02	0.0000E+00	-3.2762E+01	0.0000E+00	0.0000E+00
a_4	3.1103E-01	5.8903E-02	1.5694E-02	2.1988E-01	-1.0778E-01	-9.0251E-02
a_6	-4.0069E-01	-1.5239E-01	-3.0856E-01	-6.2106E-01	-2.7114E-02	6.1456E-02
a_8	3.6098E-01	-2.0094E-01	-8.6911E-02	3.1010E-01	1.3368E-01	1.5173E-01
a_{10}	-2.0696E-01	2.0486E-01	2.8045E-01	1.1376E-01	5.1418E-02	4.2087E-02
a_{12}	8.7281E-02	3.9777E-01	4.0294E-01	-1.2007E-01	0.0000E+00	0.0000E+00
a_{14}	-4.1297E-01	3.6978E-02	-1.4256E-01	-2.1129E-01	0.0000E+00	0.0000E+00
a_{16}	3.3921E-01	-6.9633E-01	-3.8040E-01	2.5943E-01	0.0000E+00	0.0000E+00
Surface #	1141	1142	1151	1152	1161	1162
K	-3.1379E+01	-1.6758E+00	-5.7869E+00	-5.0993E+00	0.0000E+00	0.0000E+00
a_4	-5.3858E-02	1.5537E-01	-2.2376E-01	-1.5627E-01	-2.1209E-01	-1.8673E-01
a_6	2.8953E-01	-1.1436E-01	4.6665E-02	2.9248E-02	2.5365E-02	4.7983E-02
a_8	-3.0892E-01	5.7170E-02	-1.5237E-02	-1.2732E-02	7.3904E-03	-6.9718E-03
a_{10}	2.2847E-01	1.3112E-01	6.1433E-04	2.3020E-03	-1.4429E-03	7.9077E-05
a_{12}	-1.8836E-01	-1.3340E-01	2.1838E-03	-8.5032E-05	0.0000E+00	0.0000E+00
a_{14}	8.6444E-02	1.2426E-02	7.9966E-04	-1.2405E-04	0.0000E+00	0.0000E+00
a_{16}	-4.4665E-02	1.1817E-02	8.1513E-05	1.4534E-04	0.0000E+00	0.0000E+00

FIG. 49

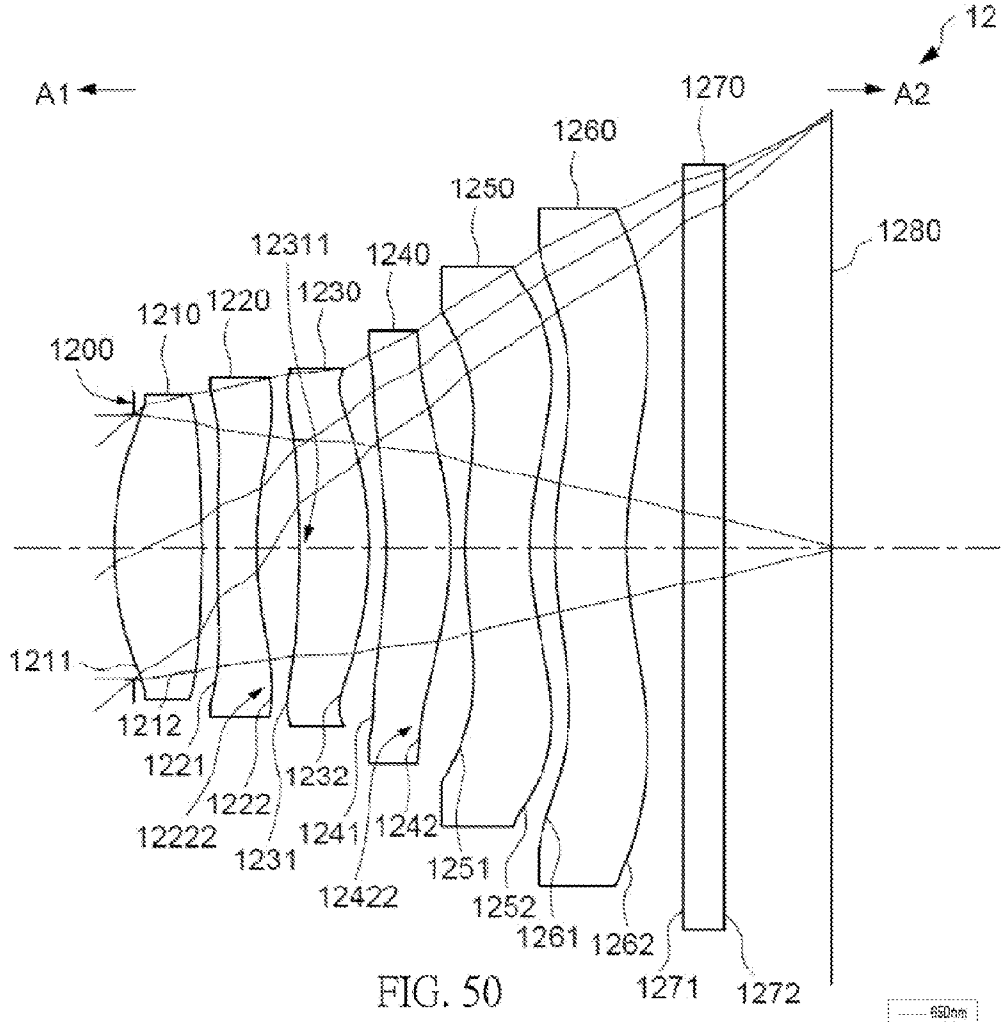

12
A1
A2
1270
1260
1250
1280
12311
1240
1230
1220
1210
1200
1211
1212
1221
1222
12222
1232
1231
1241
1242
12422
1251
1252
1261
1262
1271
1272

FIG. 50

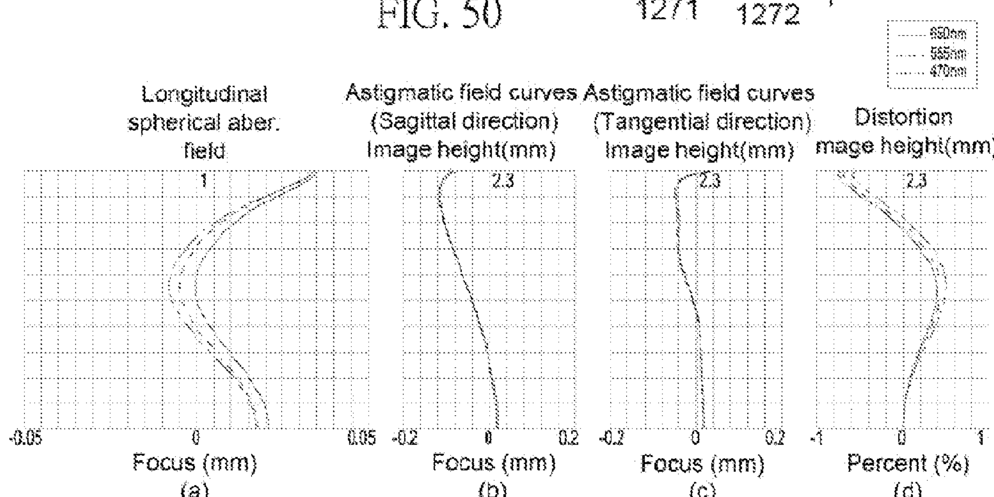

650nm
555nm
470nm
Longitudinal spherical aber. field
Astigmatic field curves (Sagittal direction) Image height(mm)
Astigmatic field curves (Tangential direction) Image height(mm)
Distortion mage height(mm)
1
2.3
2.3
2.3
-0.05
0
0.05
-0.2
0
0.2
-0.2
0
0.2
-1
0
1
Focus (mm)
(a)
Focus (mm)
(b)
Focus (mm)
(c)
Percent (%)
(d)

FIG. 51

EFL(Effective focus length)= 2.781mm, HFOV(Half angular field of view)= 39.966deg., System length=3.787mm, Image heigh= 2.3mm, Fno=2.0							
Surface #		Radius	Thickness	Refractive index	Abbe number	Focus	Material
-	Object	∞	∞				
1200	Aperture stop	∞	-0.100				
1211	1st lens element	1.687	0.465	1.535	55.712	2.462	plastic
1212		-5.513	0.080				
1221	2nd lens element	12.246	0.208	1.643	22.437	-3.740	plastic
1222		2.009	0.221				
1231	3rd lens element	-8.803	0.371	1.535	55.712	5.036	plastic
1232		-2.099	0.094				
1241	4th lens element	-2.328	0.337	1.535	55.712	10.327	plastic
1242		-1.722	0.079				
1251	5th lens element	2.484	0.339	1.535	55.712	-9.179	plastic
1252		1.573	0.132				
1261	6th lens element	2.164	0.379	1.531	55.744	196.102	plastic
1262		2.075	0.300				
1271	IR cut filter	∞	0.210	1.517	64.167		plastic
1272		∞	0.571				
1280	Image plane	∞	0.000				

FIG. 52

Aspherical parameters						
Surface #	1211	1212	1221	1222	1231	1232
K	-1.3561E+01	-1.3535E+02	0.0000E+00	-2.8780E+01	0.0000E+00	0.0000E+00
a_4	3.0887E-01	4.6851E-02	8.9235E-03	2.1766E-01	-1.1402E-01	-9.5477E-02
a_6	-4.0181E-01	-1.4504E-01	-3.2601E-01	-6.1247E-01	-8.7123E-03	6.4914E-02
a_8	3.4862E-01	-2.2874E-01	-7.5346E-02	3.0111E-01	1.5306E-01	1.5418E-01
a_{10}	-2.4051E-01	2.3757E-01	2.5655E-01	9.2146E-02	1.9337E-02	4.5619E-02
a_{12}	6.8696E-02	2.6155E-01	3.2422E-01	-1.5641E-01	0.0000E+00	0.0000E+00
a_{14}	-3.7407E-01	7.1085E-03	-1.4623E-01	-1.0331E-01	0.0000E+00	0.0000E+00
a_{16}	3.8290E-01	-5.9286E-01	-2.3589E-01	2.2237E-01	0.0000E+00	0.0000E+00
Surface #	1241	1242	1251	1252	1261	1262
K	-2.9426E+01	-1.5129E+00	-5.8442E+00	-5.2252E+00	0.0000E+00	0.0000E+00
a_4	-5.2807E-02	1.5264E-01	-2.2170E-01	-1.5248E-01	-2.1080E-01	-1.8930E-01
a_6	2.8727E-01	-1.1832E-01	4.5490E-02	3.0921E-02	2.5544E-02	4.7711E-02
a_8	-3.0442E-01	5.7813E-02	-1.2131E-02	-1.2147E-02	7.3749E-03	-7.0120E-03
a_{10}	2.3554E-01	1.3218E-01	8.9111E-04	2.4052E-03	-1.4359E-03	5.9870E-05
a_{12}	-1.8228E-01	-1.3281E-01	2.0126E-03	-7.3381E-05	0.0000E+00	0.0000E+00
a_{14}	9.1092E-02	1.2256E-02	9.0585E-04	-1.2211E-04	0.0000E+00	0.0000E+00
a_{16}	-4.1785E-02	1.1363E-02	9.4541E-05	1.3527E-04	0.0000E+00	0.0000E+00

FIG. 53

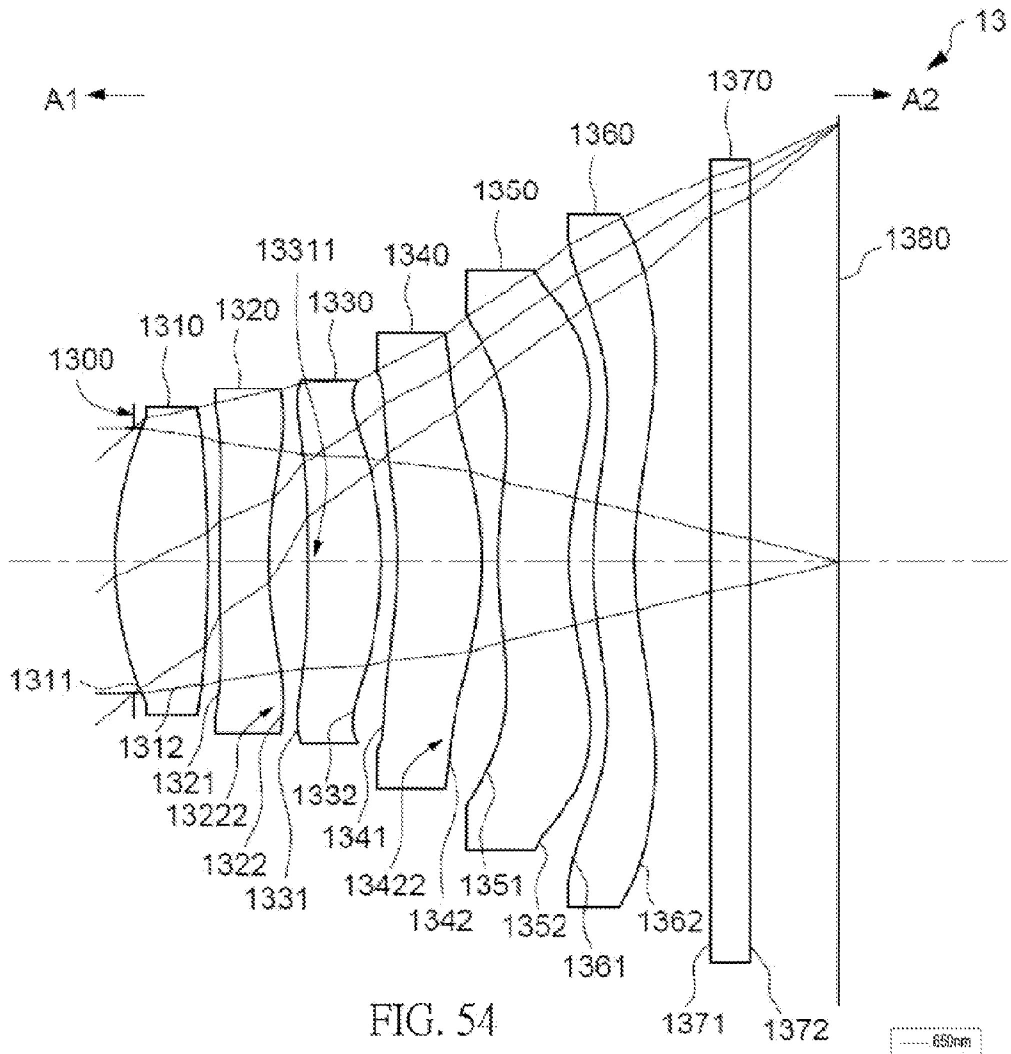

13
A1
A2
1370
1360
1350
1380
13311
1340
1330
1320
1310
1300
1311
1312
1321
13222
1322
1331
1332
1341
13422
1342
1351
1352
1361
1362
1371
1372

FIG. 54

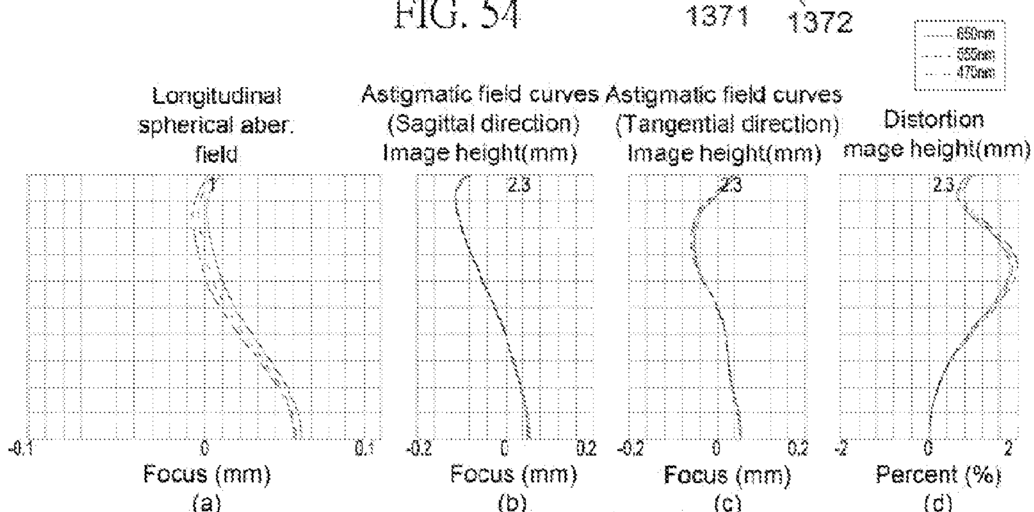

650nm
555nm
470nm
Longitudinal spherical aber. field
Astigmatic field curves (Sagittal direction) Image height(mm)
Astigmatic field curves (Tangential direction) Image height(mm)
Distortion mage height(mm)
1
2.3
2.3
2.3
-0.1
0
0.1
-0.2
0
0.2
-0.2
0
0.2
-2
0
2
Focus (mm)
(a)
Focus (mm)
(b)
Focus (mm)
(c)
Percent (%)
(d)

FIG. 55

EFL(Effective focus length)= 2.778mm, HFOV(Half angular field of view)= 39.868deg., System length=3.802mm, Image heigh= 2.3mm, Fno=2.0							
Surface #		Radius	Thickness	Refractive index	Abbe number	Focus	Material
-	Object	∞	∞				
1300	Aperture stop	∞	-0.100				
1311	1st lens element	1.722	0.487	1.535	55.712	2.467	plastic
1312		-5.168	0.065				
1321	2nd lens element	12.940	0.257	1.643	22.437	-3.775	plastic
1322		2.041	0.206				
1331	3rd lens element	-10.598	0.385	1.535	55.712	4.975	plastic
1332		-2.160	0.084				
1341	4th lens element	-2.421	0.441	1.535	55.712	9.366	plastic
1342		-1.738	0.090				
1351	5th lens element	2.465	0.374	1.535	55.712	-9.776	plastic
1352		1.588	0.127				
1361	6th lens element	2.171	0.215	1.531	55.744	-278.533	plastic
1362		2.066	0.400				
1371	IR cut filter	∞	0.210	1.517	64.167		plastic
1372		∞	0.462				
1380	Image plane	∞	0.000				

FIG. 56

Aspherical parameters						
Surface #	1311	1312	1321	1322	1331	1332
K	-1.4246E+01	-1.3576E+02	0.0000E+00	-3.0921E+01	0.0000E+00	0.0000E+00
a_4	3.0997E-01	5.5910E-02	2.1808E-02	2.1972E-01	-1.0910E-01	-9.0021E-02
a_6	-4.0229E-01	-1.5182E-01	-3.0377E-01	-6.2597E-01	-2.9576E-02	6.1668E-02
a_8	3.5988E-01	-1.9201E-01	-8.7560E-02	3.0670E-01	1.3352E-01	1.5119E-01
a_{10}	-2.0568E-01	2.2067E-01	2.8101E-01	1.1309E-01	5.2137E-02	4.0951E-02
a_{12}	9.1657E-02	4.1764E-01	4.0400E-01	-1.1799E-01	0.0000E+00	0.0000E+00
a_{14}	-3.9244E-01	4.7544E-02	-1.4382E-01	-2.0614E-01	0.0000E+00	0.0000E+00
a_{16}	3.9110E-01	-6.9138E-01	-3.7895E-01	2.6777E-01	0.0000E+00	0.0000E+00
Surface #	1341	1342	1351	1352	1361	1362
K	-3.9691E+01	-1.4375E+00	-6.4052E+00	-5.6388E+00	0.0000E+00	0.0000E+00
a_4	-6.4395E-02	1.5123E-01	-2.2574E-01	-1.5544E-01	-2.1320E-01	-1.8812E-01
a_6	2.9052E-01	-1.1606E-01	4.7182E-02	2.8751E-02	2.5211E-02	4.7444E-02
a_8	-3.0536E-01	5.6214E-02	-1.4550E-02	-1.3043E-02	7.3631E-03	-7.0793E-03
a_{10}	2.3142E-01	1.3074E-01	8.7274E-04	2.2370E-03	-1.4475E-03	6.6234E-05
a_{12}	-1.8708E-01	-1.3350E-01	2.2501E-03	-7.5967E-05	0.0000E+00	0.0000E+00
a_{14}	8.6030E-02	1.2379E-02	8.1480E-04	-1.0883E-04	0.0000E+00	0.0000E+00
a_{16}	-4.6342E-02	1.1829E-02	8.4715E-05	1.5469E-04	0.0000E+00	0.0000E+00

FIG. 57

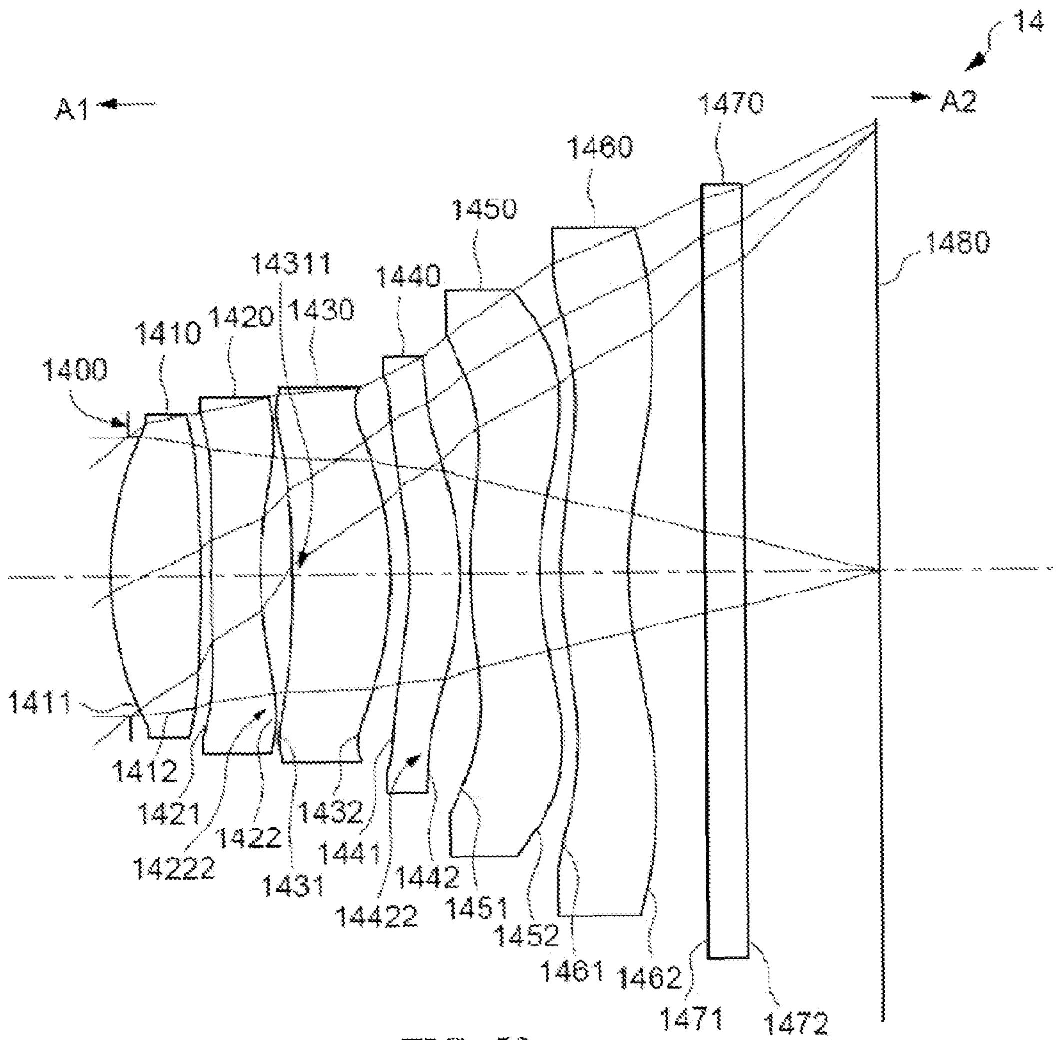

14
A1
A2
1470
1460
1450
1480
14311
1440
1420
1430
1410
1400
1411
1412
1421
1422
14222
1431
1432
1441
1442
14422
1451
1452
1461
1462
1471
1472

FIG. 58

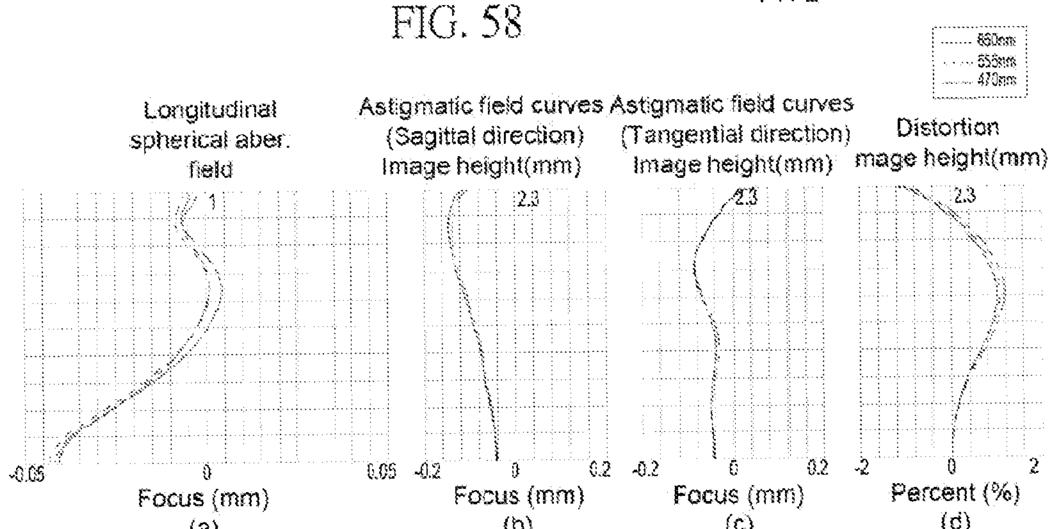

Longitudinal spherical aber. field
Astigmatic field curves (Sagittal direction) Image height(mm)
Astigmatic field curves (Tangential direction) Image height(mm)
Distortion mage height(mm)
1
2.3
2.3
2.3
-0.05
0
0.05
-0.2
0
0.2
-0.2
0
0.2
-2
0
2
Focus (mm)
(a)
Focus (mm)
(b)
Focus (mm)
(c)
Percent (%)
(d)

FIG. 59

EFL(Effective focus length)= 2.900mm, HFOV(Half angular field of view)= 38.324deg., System length= 4.015mm, Image heigh= 2.3mm, Fno=2.0							
Surface #		Radius	Thickness	Refractive index	Abbe number	Focus	Material
-	Object	∞	∞				
1400	Aperture stop	∞	-0.100				
1411	1st lens element	1.658	0.471	1.535	55.712	2.401	plastic
1412		-5.209	0.057				
1421	2nd lens element	18.829	0.256	1.643	22.437	-3.438	plastic
1422		1.981	0.168				
1431	3rd lens element	-6.249	0.508	1.535	55.712	5.663	plastic
1432		-2.103	0.101				
1441	4th lens element	-1.829	0.267	1.535	55.712	10.340	plastic
1442		-1.446	0.050				
1451	5th lens element	2.266	0.361	1.535	55.712	-11.362	plastic
1452		1.560	0.110				
1461	6th lens element	2.070	0.355	1.531	55.744	226.126	plastic
1462		1.981	0.400				
1471	IR cut filter	∞	0.210	1.517	64.167		plastic
1472		∞	0.700				
1480	Image plane	∞	0.000				

FIG. 60

Aspherical parameters						
Surface #	1411	1412	1421	1422	1431	1432
K	-1.3910E+01	-2.1868E+02	0.0000E+00	-2.8048E+01	0.0000E+00	0.0000E+00
a_4	3.1826E-01	5.0033E-02	1.8166E-02	2.1276E-01	-1.0701E-01	-1.1016E-01
a_6	-3.9805E-01	-1.5520E-01	-3.1386E-01	-6.3041E-01	-2.7953E-02	5.2713E-02
a_8	3.6118E-01	-1.9884E-01	-1.0010E-01	3.0518E-01	1.2791E-01	1.4246E-01
a_{10}	-2.0265E-01	2.1230E-01	2.6434E-01	1.1247E-01	4.9098E-02	3.1722E-02
a_{12}	9.5387E-02	4.0999E-01	3.8418E-01	-1.1985E-01	0.0000E+00	0.0000E+00
a_{14}	-3.9466E-01	5.5301E-02	-1.5892E-01	-2.1106E-01	0.0000E+00	0.0000E+00
a_{16}	3.8313E-01	-6.8057E-01	-3.9520E-01	2.5830E-01	0.0000E+00	0.0000E+00
Surface #	1441	1442	1451	1452	1461	1462
K	-2.0973E+01	-2.2606E+00	-9.5632E+00	-5.1833E+00	0.0000E+00	0.0000E+00
a_4	-5.5551E-02	1.6548E-01	-2.1463E-01	-1.6082E-01	-2.0920E-01	-1.8458E-01
a_6	2.9109E-01	-1.1739E-01	5.0663E-02	3.1585E-02	2.6047E-02	4.7685E-02
a_8	-3.0061E-01	5.4439E-02	-1.4955E-02	-1.1324E-02	7.3724E-03	-7.1780E-03
a_{10}	2.3381E-01	1.3009E-01	9.4024E-04	2.4004E-03	-1.5135E-03	-1.0513E-05
a_{12}	-1.8544E-01	-1.3348E-01	2.5036E-03	-1.8044E-04	0.0000E+00	0.0000E+00
a_{14}	9.0158E-02	1.2774E-02	9.1612E-04	-1.7070E-04	0.0000E+00	0.0000E+00
a_{16}	-3.7746E-02	1.2433E-02	2.9061E-06	1.3899E-04	0.0000E+00	0.0000E+00

FIG. 61

Embodiment	1st Embodiment	2nd Embodiment	3rd Embodiment	4th Embodiment	5th Embodiment	6th Embodiment	7th Embodiment
T1	0.637	0.638	0.844	0.862	0.846	0.899	0.474
A12	0.068	0.057	0.070	0.066	0.072	0.074	0.075
T2	0.200	0.205	0.230	0.232	0.225	0.217	0.227
G23	0.224	0.168	0.282	0.258	0.211	0.188	0.210
T3	0.315	0.469	0.415	0.489	0.619	0.452	0.374
G34	0.185	0.089	0.320	0.205	0.121	0.268	0.085
T4	0.462	0.477	0.544	0.631	0.677	0.761	0.413
G45	0.069	0.051	0.069	0.057	0.030	0.029	0.092
T5	0.461	0.512	0.461	0.435	0.440	0.472	0.384
G56	0.206	0.088	0.068	0.053	0.028	0.030	0.134
T6	0.329	0.328	0.359	0.373	0.399	0.622	0.251
BFL	0.976	1.051	1.143	1.209	1.286	1.372	1.064
EFL	3.016	3.037	3.323	3.342	3.344	3.824	2.820
ALT	2.404	2.628	2.853	3.022	3.206	3.423	2.123
AAG	0.752	0.453	0.809	0.638	0.463	0.589	0.595
EFL/(T2+T6)	5.700	5.703	5.645	5.521	5.361	4.557	5.900
BFL/T4	2.113	2.206	2.103	1.916	1.899	1.804	2.575
AAG/T3	2.391	0.965	1.946	1.306	0.747	1.304	1.593
ALT/T6	7.308	8.017	7.955	8.101	8.031	5.505	8.453
EFL/AAG	4.009	6.706	4.109	5.235	7.224	6.491	4.737
BFL/(G12+G23)	3.343	4.675	3.246	3.730	4.539	5.249	3.737
ALT/BFL	2.462	2.500	2.495	2.500	2.493	2.495	1.996
(T5+T6)/(G34+G45+G56)	1.717	3.684	1.797	2.571	4.676	3.337	2.044
ALT+AAG	3.156	3.081	3.661	3.661	3.669	4.012	2.719
T3/(G12+G56)	1.147	3.256	3.019	4.111	6.156	4.352	1.794
ALT/(G34+G56)	6.139	14.874	7.364	11.738	21.402	11.471	9.715
T4/T5	1.002	0.931	1.179	1.449	1.540	1.611	1.075
AAG/T2	3.759	2.212	3.515	2.748	2.061	2.709	2.624
T1/(G23+G56)	1.480	2.491	2.412	2.776	3.531	4.133	1.381

FIG. 62A

Embodiment	8th Embodiment	9th Embodiment	10th Embodiment	11th Embodiment	12th Embodiment	13th Embodiment	14th Embodiment
T1	0.445	0.489	0.484	0.472	0.465	0.487	0.471
A12	0.065	0.078	0.069	0.077	0.080	0.065	0.057
T2	0.305	0.224	0.212	0.233	0.208	0.257	0.256
G23	0.226	0.195	0.207	0.230	0.221	0.206	0.168
T3	0.367	0.352	0.401	0.297	0.371	0.385	0.508
G34	0.103	0.070	0.086	0.115	0.094	0.084	0.101
T4	0.372	0.552	0.289	0.412	0.337	0.441	0.267
G45	0.071	0.064	0.121	0.142	0.079	0.090	0.050
T5	0.329	0.424	0.321	0.387	0.339	0.374	0.361
G56	0.129	0.153	0.127	0.147	0.132	0.127	0.110
T6	0.403	0.264	0.286	0.256	0.379	0.215	0.355
BFL	1.022	0.997	1.262	1.031	1.081	1.072	1.310
EFL	2.822	2.865	2.897	2.883	2.781	2.778	2.900
ALT	2.222	2.305	1.994	2.057	2.099	2.158	2.219
AAG	0.595	0.560	0.609	0.712	0.606	0.571	0.486
EFL/(T2+T6)	3.982	5.865	5.810	5.894	4.738	5.890	4.744
BFL/T4	2.745	1.807	4.364	2.502	3.208	2.432	4.907
AAG/T3	1.623	1.592	1.519	2.396	1.632	1.485	0.955
ALT/T6	5.508	8.718	6.967	8.046	5.536	10.050	6.245
EFL/AAG	4.740	5.112	4.753	4.050	4.589	4.863	5.970
BFL/(G12+G23)	3.507	3.642	4.568	3.354	3.598	3.962	5.812
ALT/BFL	2.174	2.312	1.579	1.996	1.942	2.012	1.693
(T5+T6)/(G34+G45+G56)	2.411	2.401	1.823	1.589	2.350	1.958	2.751
ALT+AAG	2.818	2.865	2.604	2.769	2.705	2.729	2.704
T3/(G12+G56)	1.884	1.523	2.049	1.323	1.748	2.004	3.043
ALT/(G34+G56)	9.545	10.350	9.380	7.844	9.282	10.254	10.530
T4/T5	1.131	1.302	0.901	1.064	0.995	1.179	0.740
AAG/T2	1.951	2.501	2.869	3.049	2.917	2.223	1.897
T1/(G23+G56)	1.252	1.404	1.448	1.251	1.319	1.463	1.690

FIG. 62B

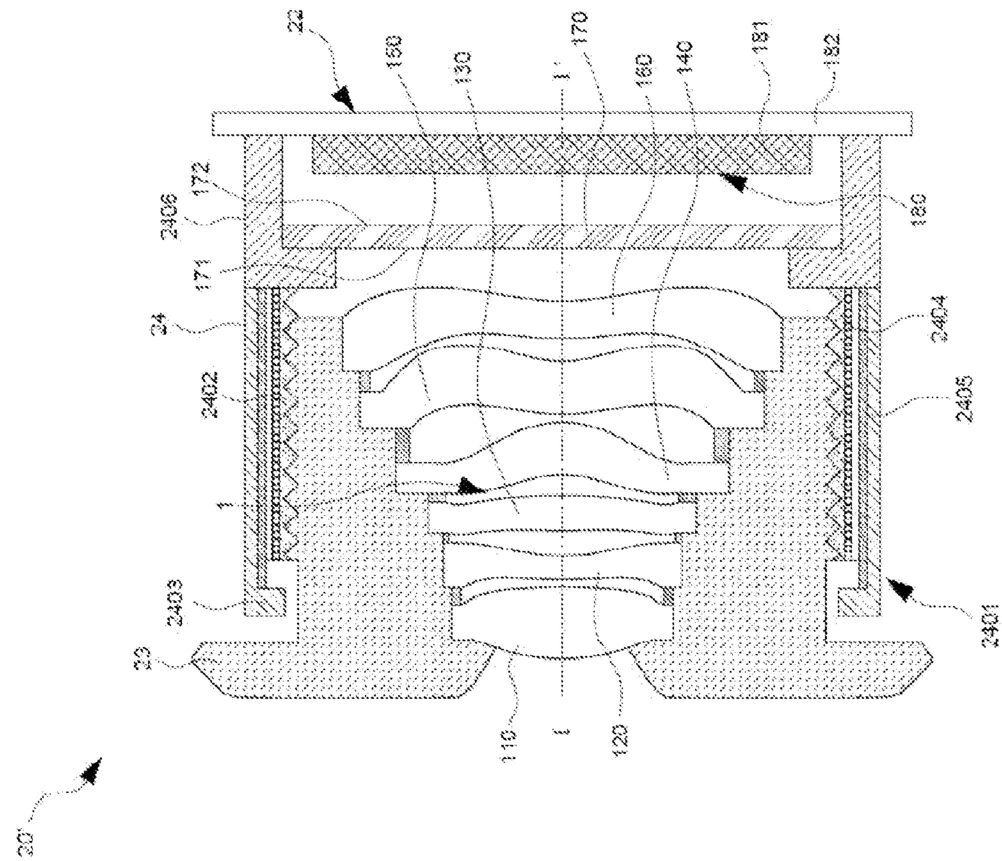

22
150
130
1'
170
160
140
181
182
172
2406
171
24
2402
1
2403
23
110
1
120
2401
2405
2404
180
20'

FIG. 64

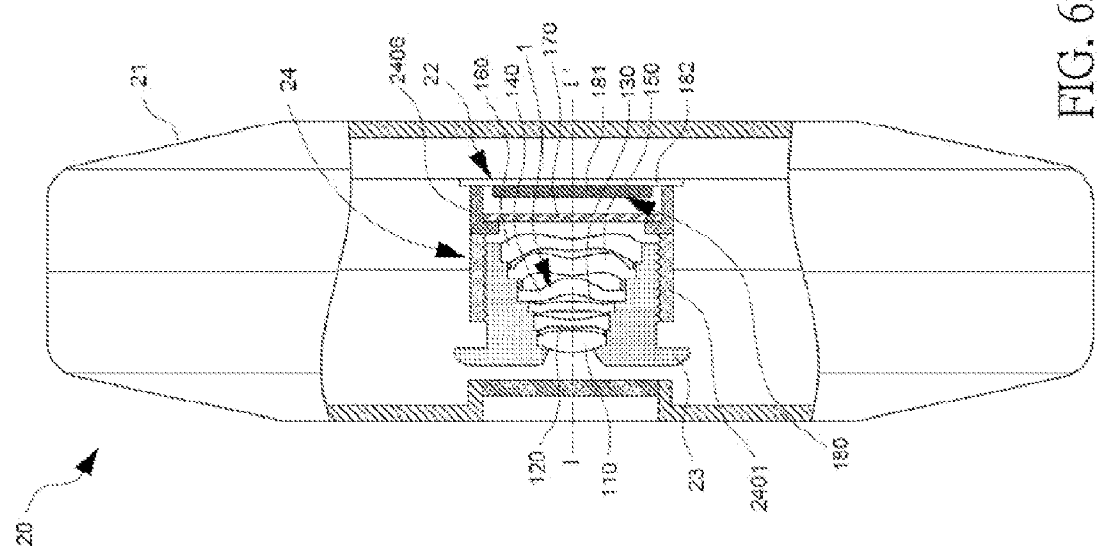

21
24
2406
22
160
140
1
170
1'
181
130
150
182
120
1
110
23
2401
180
20

FIG. 63

MOBILE DEVICE AND OPTICAL IMAGING LENS THEREOF

INCORPORATION BY REFERENCE

This application claims priority from P.R.C. Patent Application No. 201510034278.5, filed on Jan. 23, 2015, the contents of which are hereby incorporated by reference in their entirety for all purposes.

TECHNICAL FIELD

The present disclosure relates to a mobile device and an optical imaging lens thereof, and particularly, relates to a mobile device applying an optical imaging lens having six lens elements and an optical imaging lens thereof.

BACKGROUND

The ever-increasing demand for smaller sized mobile devices, such as cell phones, digital cameras, etc. has triggered a corresponding and growing need for smaller sized photography modules. Such modules may comprise elements such as an optical imaging lens, a module housing unit, and an image sensor, etc., contained therein. Size reductions may be contributed from various aspects of the mobile devices, which may include not only the charge coupled device (CCD) and the complementary metal-oxide semiconductor (CMOS), but also the optical imaging lens mounted therein. When reducing the size of the optical imaging lens, however, achieving good optical characteristics may present a challenging problem.

According to current technological development, such as the optical imaging lenses in Taiwan Patent No. M471594 and I424271, both of which relate to optical imaging lens constructed with an optical imaging lens having six lens elements, the length of the optical imaging lens, from the object-side surface of the first lens element to the image plane is longer. These optical imaging lenses are too long for smaller sized mobile devices. Therefore, there is a need for optical imaging lens which may be capable to place with six lens elements therein, with a shorter length, while also having good optical characteristics.

SUMMARY

Embodiments of the present disclosure may provide a mobile device and an optical imaging lens thereof. By controlling the convex or concave shape of the surfaces, the length of the optical imaging lens may be shortened while maintaining good optical characteristics and system functionality.

In an exemplary embodiment, an optical imaging lens may comprise, sequentially from an object side to an image side along an optical axis, an aperture stop, first, second, third, fourth, fifth and sixth lens elements. Each of the first, second, third, fourth, fifth and sixth lens elements may have refracting power, an object-side surface facing toward the object side and an image-side surface facing toward the image side, and a central thickness defined along the optical axis.

In the specification, parameters used here are: the central thickness of the first lens element, represented by T1, an air gap between the first lens element and the second lens element along the optical axis, represented by G12, the central thickness of the second lens element, represented by T2, an air gap between the second lens element and the third

lens element along the optical axis, represented by G23, the central thickness of the third lens element, represented by T3, an air gap between the third lens element and the fourth lens element along the optical axis, represented by G34, the central thickness of the fourth lens element, represented by T4, an air gap between the fourth lens element and the fifth lens element along the optical axis, represented by G45, the central thickness of the fifth lens element, represented by T5, an air gap between the fifth lens element and the sixth lens element along the optical axis, represented by G56, the central thickness of the sixth lens element, represented by T6, a distance between the image-side surface of the sixth lens element and the object-side surface of a filtering unit along the optical axis, represented by G6F, the central thickness of the filtering unit along the optical axis, represented by TF, a distance between the image-side surface of the filtering unit and an image plane along the optical axis, represented by GFP, a focusing length of the first lens element, represented by f1, a focusing length of the second lens element, represented by f2, a focusing length of the third lens element, represented by f3, a focusing length of the fourth lens element, represented by f4, a focusing length of the fifth lens element, represented by f5, a focusing length of the sixth lens element, represented by f6, the refracting index of the first lens element, represented by n1, the refracting index of the second lens element, represented by n2, the refracting index of the third lens element, represented by n3, the refracting index of the fourth lens element, represented by n4, the refracting index of the fifth lens element, represented by n5, the refracting index of the sixth lens element, represented by n6, an abbe number of the first lens element, represented by v1, an abbe number of the second lens element, represented by v2, an abbe number of the third lens element, represented by v3, an abbe number of the fourth lens element, represented by v4, an abbe number of the fifth lens element, represented by v5, an abbe number of the sixth lens element, represented by v6, an effective focal length of the optical imaging lens, represented by EFL, a distance between the object-side surface of the first lens element and an image plane along the optical axis, represented by TTL, a sum of the central thicknesses of all six lens elements, i.e. a sum of T1, T2, T3, T4, T5 and T6, represented by ALT, a sum of all five air gaps from the first lens element to the sixth lens element along the optical axis, i.e. a sum of G12, G23, G34, G45 and G56, represented by AAG, a back focal length of the optical imaging lens, which is defined as the distance from the image-side surface of the sixth lens element to the image plane along the optical axis, i.e. a sum of G6F, TF and GFP, and represented by BFL.

In an aspect of the optical imaging lens of the present disclosure, the image-side surface of the first lens may comprise a convex portion in a vicinity of the optical axis; the object-side surface of the second lens element may comprise a concave portion in a vicinity of the periphery of the second lens element; the object-side surface of the third lens element may comprise a convex portion in a vicinity of the periphery of the third lens element; the fourth lens element may be constructed by plastic material; the image-side surface of the fifth lens element may comprise a concave portion in a vicinity of the optical axis; the image-side surface of the sixth lens element may comprise a concave portion in a vicinity of the optical axis. In some embodiments, the optical imaging lens may comprise no other lenses having refracting power beyond the six lens elements.

In another exemplary embodiment, other equation(s), such as those relating to the ratio among parameters may be taken into consideration. For example, EFL, T2 and T6 could be controlled to satisfy the equation as follows:

$$EFL/(T2+T6)\leq 5.9 \quad \text{Equation (1); or}$$

BFL and T4 could be controlled to satisfy the equation as follows:

$$1.8\leq BFL/T4 \quad \text{Equation (2); or}$$

T5, T6, G34, G45 and G56 could be controlled to satisfy the equation as follows:

$$1.5\leq (T5+T6)/(G34+G45+G56) \quad \text{Equation (3); or}$$

AAG and T3 could be controlled to satisfy the equation as follows:

$$AAG/T3\leq 2.4 \quad \text{Equation (4); or}$$

ALT and AAG could be controlled to satisfy the equation as follows:

$$ALT+AAG\leq 6 \quad \text{Equation (5); or}$$

ALT and T6 could be controlled to satisfy the equation as follows:

$$5.5\leq ALT/T6 \quad \text{Equation (6); or}$$

T3, G12 and G56 could be controlled to satisfy the equation as follows:

$$1.0\leq T3/(G12+G56) \quad \text{Equation (7); or}$$

EFL and AAG could be controlled to satisfy the equation as follows:

$$4.0\leq EFL/AAG \quad \text{Equation (8); or}$$

ALT, G34 and G56 could be controlled to satisfy the equation as follows:

$$4.6\leq ALT/(G34+G56) \quad \text{Equation (9); or}$$

T4 and T5 could be controlled to satisfy the equation as follows:

$$T4/T5\leq 1.5 \quad \text{Equation (10);or}$$

BFL, G12 and G23 could be controlled to satisfy the equation as follows:

$$3.0\leq BFL/(G12+G23) \quad \text{Equation (11);or}$$

AAG and T2 could be controlled to satisfy the equation as follows:

$$AAG/T2\leq 3.8 \quad \text{Equation (12);or}$$

ALT and BFL could be controlled to satisfy the equation as follows:

$$ALT/BFL\leq 2.5 \quad \text{Equation (13);or}$$

T1, G23 and G56 could be controlled to satisfy the equation as follows:

$$1.25\leq T1/(G23+G56) \quad \text{Equation (14).}$$

Aforesaid exemplary embodiments are not limited and could be selectively incorporated in other embodiments described herein.

In some exemplary embodiments, more details about the convex or concave surface structure could be incorporated for one specific lens element or broadly for plural lens elements to enhance the control for the system performance and/or resolution. It is noted that the details listed here could be incorporated in example embodiments if no inconsistency occurs.

In another exemplary embodiment, a mobile device may comprise a housing and a photography module positioned in the housing is provided. The photography module may comprise any of aforesaid example embodiments of optical imaging lens, a lens barrel, a module housing unit and an image sensor. The lens barrel may be suitable for positioning the optical imaging lens, the module housing unit may be suitable for positioning the lens barrel, and the image sensor may be positioned at the image side of the optical imaging lens.

Through controlling the convex or concave shape of the surfaces, the mobile device and the optical imaging lens thereof in exemplary embodiments may achieve good optical characteristics and effectively shorten the length of the optical imaging lens.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments will be more readily understood from the following detailed description when read in conjunction with the appended drawing, in which:

FIG. **1** is a cross-sectional view of one single lens element according to the present disclosure;

FIG. **2** is a schematic view of the relation between the surface shape and the optical focus of the lens element;

FIG. **3** is a schematic view of a first example of the surface shape and the efficient radius of the lens element;

FIG. **4** is a schematic view of a second example of the surface shape and the efficient radius of the lens element;

FIG. **5** is a schematic view of a third example of the surface shape and the efficient radius of the lens element;

FIG. **6** is a cross-sectional view of a first embodiment of an optical imaging lens having six lens elements according to the present disclosure;

FIG. **7** is a chart of longitudinal spherical aberration and other kinds of optical aberrations of a first embodiment of the optical imaging lens according to the present disclosure;

FIG. **8** is a table of optical data for each lens element of the optical imaging lens of a first embodiment of the present disclosure;

FIG. **9** is a table of aspherical data of a first embodiment of the optical imaging lens according to the present disclosure;

FIG. **10** is a cross-sectional view of a second embodiment of an optical imaging lens having six lens elements according to the present disclosure;

FIG. **11** is a chart of longitudinal spherical aberration and other kinds of optical aberrations of a second embodiment of the optical imaging lens according the present disclosure;

FIG. **12** is a table of optical data for each lens element of the optical imaging lens of a second embodiment of the present disclosure;

FIG. **13** is a table of aspherical data of a second embodiment of the optical imaging lens according to the present disclosure;

FIG. **14** is a cross-sectional view of a third embodiment of an optical imaging lens having six lens elements according to the present disclosure;

FIG. **15** is a chart of longitudinal spherical aberration and other kinds of optical aberrations of a third embodiment of the optical imaging lens according the present disclosure;

FIG. **16** is a table of optical data for each lens element of the optical imaging lens of a third embodiment of the present disclosure;

FIG. **17** is a table of aspherical data of a third embodiment of the optical imaging lens according to the present disclosure;

FIG. **18** is a cross-sectional view of a fourth embodiment of an optical imaging lens having six lens elements according to the present disclosure;

FIG. **19** is a chart of longitudinal spherical aberration and other kinds of optical aberrations of a fourth embodiment of the optical imaging lens according the present disclosure;

FIG. **20** is a table of optical data for each lens element of the optical imaging lens of a fourth embodiment of the present disclosure;

FIG. **21** is a table of aspherical data of a fourth embodiment of the optical imaging lens according to the present disclosure;

FIG. **22** is a cross-sectional view of a fifth embodiment of an optical imaging lens having six lens elements according to the present disclosure;

FIG. **23** is a chart of longitudinal spherical aberration and other kinds of optical aberrations of a fifth embodiment of the optical imaging lens according the present disclosure;

FIG. **24** is a table of optical data for each lens element of the optical imaging lens of a fifth embodiment of the present disclosure;

FIG. **25** is a table of aspherical data of a fifth embodiment of the optical imaging lens according to the present disclosure;

FIG. **26** is a cross-sectional view of a sixth embodiment of an optical imaging lens having six lens elements according to the present disclosure;

FIG. **27** is a chart of longitudinal spherical aberration and other kinds of optical aberrations of a sixth embodiment of the optical imaging lens according to the present disclosure;

FIG. **28** is a table of optical data for each lens element of a sixth embodiment of an optical imaging lens according to the present disclosure;

FIG. **29** is a table of aspherical data of a sixth embodiment of the optical imaging lens according to the present disclosure;

FIG. **30** is a cross-sectional view of a seventh embodiment of an optical imaging lens having six lens elements according to the present disclosure;

FIG. **31** is a chart of longitudinal spherical aberration and other kinds of optical aberrations of a seventh embodiment of the optical imaging lens according to the present disclosure;

FIG. **32** is a table of optical data for each lens element of the optical imaging lens of a seventh embodiment of the present disclosure;

FIG. **33** is a table of aspherical data of a seventh embodiment of the optical imaging lens according to the present disclosure;

FIG. **34** is a cross-sectional view of a eighth embodiment of an optical imaging lens having six lens elements according to the present disclosure;

FIG. **35** is a chart of longitudinal spherical aberration and other kinds of optical aberrations of a eighth embodiment of the optical imaging lens according the present disclosure;

FIG. **36** is a table of optical data for each lens element of the optical imaging lens of a eighth embodiment of the present disclosure;

FIG. **37** is a table of aspherical data of a eighth embodiment of the optical imaging lens according to the present disclosure;

FIG. **38** is a cross-sectional view of a ninth embodiment of an optical imaging lens having six lens elements according to the present disclosure;

FIG. **39** is a chart of longitudinal spherical aberration and other kinds of optical aberrations of a ninth embodiment of the optical imaging lens according the present disclosure;

FIG. **40** is a table of optical data for each lens element of the optical imaging lens of a ninth embodiment of the present disclosure;

FIG. **41** is a table of aspherical data of a ninth embodiment of the optical imaging lens according to the present disclosure;

FIG. **42** is a cross-sectional view of a tenth embodiment of an optical imaging lens having six lens elements according to the present disclosure;

FIG. **43** is a chart of longitudinal spherical aberration and other kinds of optical aberrations of a tenth embodiment of the optical imaging lens according the present disclosure;

FIG. **44** is a table of optical data for each lens element of the optical imaging lens of a tenth embodiment of the present disclosure;

FIG. **45** is a table of aspherical data of a tenth embodiment of the optical imaging lens according to the present disclosure;

FIG. **46** is a cross-sectional view of a eleventh embodiment of an optical imaging lens having six lens elements according to the present disclosure;

FIG. **47** is a chart of longitudinal spherical aberration and other kinds of optical aberrations of an eleventh embodiment of the optical imaging lens according the present disclosure;

FIG. **48** is a table of optical data for each lens element of the optical imaging lens of an eleventh embodiment of the present disclosure;

FIG. **49** is a table of aspherical data of an eleventh embodiment of the optical imaging lens according to the present disclosure;

FIG. **50** is a cross-sectional view of a twelfth embodiment of an optical imaging lens having six lens elements according to the present disclosure;

FIG. **51** is a chart of longitudinal spherical aberration and other kinds of optical aberrations of a twelfth embodiment of the optical imaging lens according the present disclosure;

FIG. **52** is a table of optical data for each lens element of the optical imaging lens of a twelfth embodiment of the present disclosure;

FIG. **53** is a table of aspherical data of a twelfth embodiment of the optical imaging lens according to the present disclosure;

FIG. **54** is a cross-sectional view of a thirteenth embodiment of an optical imaging lens having six lens elements according to the present disclosure;

FIG. **55** is a chart of longitudinal spherical aberration and other kinds of optical aberrations of a thirteenth embodiment of the optical imaging lens according the present disclosure;

FIG. **56** is a table of optical data for each lens element of the optical imaging lens of a thirteenth embodiment of the present disclosure;

FIG. **57** is a table of aspherical data of a thirteenth embodiment of the optical imaging lens according to the present disclosure;

FIG. **58** is a cross-sectional view of a fourteenth embodiment of an optical imaging lens having six lens elements according to the present disclosure;

FIG. **59** is a chart of longitudinal spherical aberration and other kinds of optical aberrations of a fourteenth embodiment of the optical imaging lens according the present disclosure;

FIG. **60** is a table of optical data for each lens element of the optical imaging lens of a fourteenth embodiment of the present disclosure;

FIG. **61** is a table of aspherical data of a fourteenth embodiment of the optical imaging lens according to the present disclosure;

FIG. **62**(A) and FIG. **62**(B) are two tables for the values of T1, G12, T2, G23, T3, G34, T4, G45, T5, G56, T6, BFL, EFL, ALT, AAG, EFL/(T2+T6), BFL/T4, AAG/T3, ALT/T6,

EFL/AAG, BFL/(G12+G23), ALT/BFL, (T5+T6)/(G34+G45+G56), ALT+AAG, T3/(G12+G56), ALT/(G34+G56), T4/T5, AAG/T2 and T1/(G23+G56) of all fourteen example embodiments;

FIG. **63** is a structure of an example embodiment of a mobile device;

FIG. **64** is a partially enlarged view of the structure of another example embodiment of a mobile device.

DETAILED DESCRIPTION

For a more complete understanding of the present disclosure and its advantages, reference is now made to the following description taken in conjunction with the accompanying drawings, in which like reference numbers indicate like features. Persons having ordinary skill in the art will understand other varieties for implementing example embodiments, including those described herein. The drawings are not limited to specific scale and similar reference numbers are used for representing similar elements. As used in the disclosures and the appended claims, the terms "example embodiment," "exemplary embodiment," and "present embodiment" do not necessarily refer to a single embodiment, although it may, and various example embodiments may be readily combined and interchanged, without departing from the scope or spirit of the present invention. Furthermore, the terminology as used herein is for the purpose of describing example embodiments only and is not intended to be a limitation of the invention. In this respect, as used herein, the term "in" may include "in" and "on", and the terms "a", "an" and "the" may include singular and plural references. Furthermore, as used herein, the term "by" may also mean "from", depending on the context. Furthermore, as used herein, the term "if" may also mean "when" or "upon", depending on the context. Furthermore, as used herein, the words "and/or" may refer to and encompass any and all possible combinations of one or more of the associated listed items.

In the present specification, the description "a lens element having positive refracting power (or negative refractive power)" may indicate that the paraxial refractive power of the lens element in Gaussian optics is positive (or negative). The description "an object-side (or image-side) surface of a lens element" may only include a specific region of that surface of the lens element where imaging rays are capable of passing through that region, namely the clear aperture of the surface. The aforementioned imaging rays may be classified into two types, chief ray Lc and marginal ray Lm. Taking a lens element depicted in FIG. **1** as an example, the lens element may be rotationally symmetric, where the optical axis I is the axis of symmetry. The region A of the lens element may be defined as "a part in a vicinity of the optical axis", and the region C of the lens element may be defined as "a part in a vicinity of a periphery of the lens element." Besides, the lens element may also have an extending part E extended radially and outwardly from the region C, namely the part outside of the clear aperture of the lens element. The extending part E may usually be used for physically assembling the lens element into an optical imaging lens system. Under normal circumstances, the imaging rays would not pass through the extending part E because those imaging rays only pass through the clear aperture. The structures and shapes of the aforementioned extending part E are only examples for technical explanation, the structures and shapes of lens elements should not be limited to these examples. Note that the extending parts of the lens element surfaces depicted in the following embodiments are partially omitted.

The following criteria are provided for determining the shapes and the parts of lens element surfaces set forth in the present specification. These criteria mainly determine the boundaries of parts under various circumstances including the part in a vicinity of the optical axis, the part in a vicinity of a periphery of a lens element surface, and other types of lens element surfaces such as those having multiple parts.

FIG. **1** is a radial cross-sectional view of a lens element. Before determining boundaries of those aforesaid parts, two referential points should be defined first, central point and transition point. The central point of a surface of a lens element may be a point of intersection of that surface and the optical axis. The transition point may be a point on a surface of a lens element, where the tangent line of that point is perpendicular to the optical axis. Additionally, if multiple transition points appear on one single surface, then these transition points are sequentially named along the radial direction of the surface with numbers starting from the first transition point. For instance, the first transition point (closest one to the optical axis), the second transition point, and the Nth transition point (farthest one to the optical axis within the scope of the clear aperture of the surface). The part of a surface of the lens element between the central point and the first transition point may be defined as the part in a vicinity of the optical axis. The part located radially outside of the Nth transition point (but still within the scope of the clear aperture) may be defined as the part in a vicinity of a periphery of the lens element. In some embodiments, there may be other parts existing or disposed between the part in a vicinity of the optical axis and the part in a vicinity of a periphery of the lens element; the numbers of parts depend on the numbers of the transition point(s). In addition, the radius of the clear aperture (or a so-called effective radius) of a surface may be defined as the radial distance from the optical axis I to a point of intersection of the marginal ray Lm and the surface of the lens element.

Referring to FIG. **2**, determining the shape of a part is convex or concave may depend on whether a collimated ray passing through that part converges or diverges. That is, while applying a collimated ray to a part to be determined in terms of shape, the collimated ray passing through that part may be bent and the ray itself or its extension line will eventually meet the optical axis. The shape of that part can be determined by whether the ray or its extension line meets (intersects) the optical axis (focal point) at the object-side or image-side. For instance, if the ray itself intersects the optical axis at the image side of the lens element after passing through a part, i.e. the focal point of this ray is at the image side (see point R in FIG. **2**), the part may be determined as having a convex shape. On the contrary, if the ray diverges after passing through a part, the extension line of the ray intersects the optical axis at the object side of the lens element, i.e. the focal point of the ray is at the object side (see point M in FIG. **2**), that part may be determined as having a concave shape. Therefore, referring to FIG. **2**, the part between the central point and the first transition point has a convex shape, the part located radially outside of the first transition point has a concave shape, and the first transition point is the point where the part having a convex shape changes to the part having a concave shape, namely the border of two adjacent parts. Alternatively, there may be another way to determine whether a part in a vicinity of the optical axis has a convex or concave shape by referring to the sign of an "R" value, which is the (paraxial) radius of curvature of a lens surface. The R value which may be used in optical design software such as Zemax and CodeV. The R value usually appears in the lens data sheet in the software. For an object-side surface, positive R may mean that the object-side surface is convex, and negative R may mean that the object-side surface is concave. Conversely, for an image-side surface, positive R may mean that the image-side surface is concave, and negative R may mean that the image-side surface is convex. The result found by using this method should be consistent as by using the other way mentioned above, which may determine surface shapes by referring to whether the focal point of a collimated ray is at the object side or the image side.

For none transition point cases, the part in a vicinity of the optical axis may be defined as the part between 0~50% of the effective radius (radius of the clear aperture) of the surface, whereas the part in a vicinity of a periphery of the lens element may be defined as the part between 50~100% of effective radius (radius of the clear aperture) of the surface.

Referring to the first example depicted in FIG. **3**, only one transition point, namely a first transition point, may appear within the clear aperture of the image-side surface of the lens element. Part I is a part in a vicinity of the optical axis, and part II is a part in a vicinity of a periphery of the lens element. The part in a vicinity of the optical axis may be determined as having a concave surface due to the R value at the image-side surface of the lens element is positive. The shape of the part in a vicinity of a periphery of the lens element may be different from that of the radially inner adjacent part, i.e. the shape of the part in a vicinity of a periphery of the lens element is different from the shape of the part in a vicinity of the optical axis; the part in a vicinity of a periphery of the lens element may have a convex shape.

Referring to the second example depicted in FIG. **4**, a first transition point and a second transition point may exist or be disposed on the object-side surface (within the clear aperture) of a lens element. In which part I is the part in a vicinity of the optical axis, and part III is the part in a vicinity of a periphery of the lens element. The part in a vicinity of the optical axis may have a convex shape because the R value at the object-side surface of the lens element is positive. The part in a vicinity of a periphery of the lens element (part III) may have a convex shape. What is more, there may be another part having a concave shape existing or disposed between the first and second transition point (part II).

Referring to a third example depicted in FIG. **5**, no transition point may exist or be disposed on the object-side surface of the lens element. In this case, the part between 0~50% of the effective radius (radius of the clear aperture) may be determined as the part in a vicinity of the optical axis, and the part between 50~100% of the effective radius may be determined as the part in a vicinity of a periphery of the lens element. The part in a vicinity of the optical axis of the object-side surface of the lens element may be determined as having a convex shape due to its positive R value, and the part in a vicinity of a periphery of the lens element may be determined as having a convex shape as well.

In the present disclosure, examples of an optical imaging lens which is a prime lens are provided. Example embodiments of an optical imaging lens may comprise a first lens element, a second lens element, a third lens element, a fourth lens element, a fifth lens element and a sixth lens element. Each of the lens elements may comprise refracting power, an object-side surface facing toward an object side and an image-side surface facing toward an image side and a central thickness defined along the optical axis. These lens elements may be arranged sequentially from the object side to the image side along an optical axis, and example embodiments of the lens may comprise no other lenses having refracting power beyond the six lens elements. The design of the detail characteristics of each lens element may provide the improved imaging quality and short optical imaging lens.

The image-side surface of the first lens element may comprise a convex portion in the vicinity of the optical axis, which may gather light efficiently. The aperture stop may be in front of the object-side surface of the first lens element, which may be beneficial for enlarging the filed angle.

The object-side surface of the second lens element may comprise a concave portion in the vicinity of the periphery of the second lens element, the object-side surface of the third lens element may comprise a convex portion in the vicinity of the periphery of the third lens element, the image-side surface of the fifth lens element may comprise a concave portion in the vicinity of the optical axis, the image-side surface of the sixth lens element may comprise a concave portion in the vicinity of the optical axis. Because the shapes of second, third, fifth, and sixth lens elements are arranged, the optical aberration, curvature of field, and distortion can be reduced and the imaging quality can be enhanced.

EFL should be decreased as soon as possible for shortening the total length of optical imaging lens and ensuring the imaging quality. Because the radius of curvature of the sixth lens element may be longer, the thickness of sixth lens element can't be too small for considering the production difficulty of the sixth lens element. EFL, T2 and T6 could be controlled to satisfy the equation: $EFL/(T2+T6) \leq 5.9$, and the more advantageous range of $EFL/(T2+T6)$ may be between about 3.9 and about 5.9.

In some embodiments, when the total length of the optical imaging lens is shortened, it may be advantageous to decrease the air gaps between these lens elements and the thickness of each lens element. BFL could be controlled to satisfy the equations: $BFL/T4 \geq 1.8$, $BFL/(G12+G23) \geq 3.0$, and $ALT/BFL \leq 2.5$, wherein the more advantageous range of $BFL/T4$ may be between about 1.8 and about 5.0, the more advantageous range of $BFL/(G12+G23)$ may be between about 3.2 and about 5.9, and the more advantageous range of ALT/BFL may be between about 1.5 and about 2.5.

Shortening the air gaps between these lens elements may advantageously shorten the total length of the optical imaging lens. If T5, T6, G34, G45, G56, T3, G12, ALT, AAG, T2, T1 could be controlled to satisfy the equations: $(T5+T6)/(G34+G45+G56) \geq 1.5$, $T3/(G12+G56) \geq 1.0$, $ALT/(G34+G56) \geq 4.6$, $AAG/T3 \leq 2.4$, $AAG/T2 \leq 3.8$, $ALT+AAG \leq 6.0$, and $T1/(G12+G56) \geq 1.25$, the total length of the optical imaging lens can be shortened and the imaging quality can be ensured, wherein the more advantageous range of $(T5+T6)/(G34+G45+G56)$ may be between about 1.5 and about 4.7, the more advantageous range of $T3/(G12+G56)$ may be between about 1.1 and about 6.2, the more advantageous range of $ALT/(G34+G56)$ may be between about 6.0 and about 21.5, the more advantageous range of $AAG/T3$ may be between about 0.7 to about 2.4, the more advantageous range of $AAG/T2$ may be between about 1.8 and about 3.8, the more advantageous range of $ALT+AAG$ may be between about 2.6 and about 4.1, and the more advantageous range of $T1/(G12+G56)$ may be between about 1.25 and about 4.2.

For shortening the length of the optical imaging lens, if AAG could be controlled to satisfy the equation: $EFL/AAG \geq 4.0$, the imaging quality of can be better, wherein the more advantageous range of EFL/AAG may be between about 4.0 and about 7.3.

The lens element may be designed to be thinner for shortening the total length of optical imaging lens. Because the radius of curvature of the sixth lens element may be longer, the thickness of the sixth lens element may be limited. If ALT, T6 could be designed to satisfy the equation: $ALT/T6 \geq 5.5$, the imaging quality may be better, wherein the more advantageous range of ALT/T6 may be between about 5.5 and about 10.1.

For shortening the total length of the optical imaging lens, because the radius of curvature of the fifth lens element is longer than the radius of curvature of the fourth lens element, shortening the thickness of the fifth lens element is limited. If T4 and T5 could be designed to satisfy the equation: $T4/T5 \leq 1.5$, the imaging quality can be better, wherein the more advantageous range of T4/T5 may be between 0.7 and 1.7.

When implementing example embodiments, more details about the convex or concave surface could be incorporated for one specific lens element or broadly for plural lens elements to enhance the control for the system performance and/or resolution. It is noted that the details listed here could be incorporated in example embodiments if no inconsistency occurs.

Several exemplary embodiments and associated optical data will now be provided for illustrating example embodiments of optical imaging lens with good optical characteristics and a shortened length. Reference is now made to FIGS. **6**-**9**. FIG. **6** illustrates an example cross-sectional view of an optical imaging lens **1** having six lens elements of the optical imaging lens according to a first example embodiment. FIG. **7** shows example charts of longitudinal spherical aberration and other kinds of optical aberrations of the optical imaging lens **1** according to an example embodiment. FIG. **8** illustrates an example table of optical data of each lens element of the optical imaging lens **1** according to an example embodiment, in which f is used for representing EFL. FIG. **9** depicts an example table of aspherical data of the optical imaging lens **1** according to an example embodiment.

As shown in FIG. **6**, the optical imaging lens **1** of the present embodiment may comprise, in order from an object side A**1** to an image side A**2** along an optical axis, an aperture stop **100**, a first lens element **110**, a second lens element **120**, a third lens element **130**, a fourth lens element **140**, a fifth lens element **150** and a sixth lens element **160**. A filtering unit **170** and an image plane **180** of an image sensor may be positioned at the image side A**2** of the optical lens **1**. Each of the first, second, third, fourth, fifth, sixth lens elements **110**, **120**, **130**, **140**, **150**, **160** and the filtering unit **170** may comprise an object-side surface **111**/**121**/**131**/**141**/**151**/**161**/**171** facing toward the object side A**1** and an image-side surface **112**/**122**/**132**/**142**/**152**/**162**/**172** facing toward the image side A**2**. The example embodiment of the filtering unit **170** illustrated is an IR cut filter (infrared cut filter) positioned between the sixth lens element **160** and an image plane **180**. The filtering unit **170** may selectively absorb light with specific wavelength from the light passing optical imaging lens **1**. For example, IR light may be absorbed, and this may prohibit the IR light which is not seen by human eyes from producing an image on the image plane **180**.

Exemplary embodiments of each lens element of the optical imaging lens **1** which may be constructed by plastic material will now be described with reference to the drawings.

An example embodiment of the first lens element **110** may have positive refracting power. The object-side surface **111** may be a convex surface comprising a convex portion **1111** in a vicinity of the optical axis and a convex portion **1112** in a vicinity of a periphery of the first lens element **110**. The image-side surface **112** may be a convex surface comprising a convex portion **1121** in a vicinity of the optical axis and a convex portion **1122** in a vicinity of the periphery of the first lens element **110**. The object-side surface **111** and the image-side surface **112** may be aspherical surfaces.

An example embodiment of the second lens element **120** may have negative refracting power. The object-side surface **121** may comprise a convex portion **1211** in a vicinity of the optical axis and a concave portion **1212** in a vicinity of a periphery of the second lens element **120**. The image-side surface **122** may have a concave surface comprising a concave portion **1221** in a vicinity of the optical axis and a concave portion **1222** in a vicinity of the periphery of the second lens element **120**. The object-side surface **121** and the image-side surface **122** may be aspherical surfaces.

An example embodiment of the third lens element **130** may have positive refracting power. The object-side surface **131** may have a convex surface comprising a convex portion **1311** in a vicinity of the optical axis and a convex portion **1312** in a vicinity of a periphery of the third lens element **130**. The image-side surface **132** may comprise a convex portion **1321** in a vicinity of the optical axis and a concave portion **1322** in a vicinity of the periphery of the third lens element **130**. The object-side surface **131** and the image-side surface **132** may be aspherical surfaces.

An example embodiment of the fourth lens element **140** may have positive refracting power. The object-side surface **141** may be a concave surface comprising a concave portion **1411** in a vicinity of the optical axis and a concave portion **1412** in a vicinity of a periphery of the fourth lens element **140**. The image-side surface **142** may comprise a convex portion **1421** in a vicinity of the optical axis and a concave portion **1422** in a vicinity of the periphery of the fourth lens element **140**. The object-side surface **141** and the image-side surface **142** may be aspherical surfaces.

An example embodiment of the fifth lens element **150** may have negative refracting power. The object-side surface **151** may comprise a convex portion **1511** in a vicinity of the optical axis and a concave portion **1512** in a vicinity of a periphery of the fifth lens element **150**. The image-side surface **152** may comprise a concave portion **1521** in a vicinity of the optical axis and a convex portion **1522** in a vicinity of the periphery of the fifth lens element **150**. The object-side surface **151** and the image-side surface **152** may be aspherical surfaces.

An example embodiment of the sixth lens element **160** may comprise negative refracting power. The object-side surface **161** may comprise a convex portion **1611** in a vicinity of the optical axis and a concave portion **1612** in a vicinity of a periphery of the sixth lens element **160**. The image-side surface **162** may comprise a concave portion **1621** in a vicinity of the optical axis and a convex portion **1622** in a vicinity of the periphery of the sixth lens element **160**. The object-side surface **161** and the image-side surface **162** may be aspherical surfaces.

In example embodiments, air gaps may exist or be disposed between the lens elements **110**, **120**, **130**, **140**, **150**, **160**, the filtering unit **170** and the image plane **180** of the image sensor. For example, FIG. **1** illustrates the air gap d**1** existing between the first lens element **110** and the second lens element **120**, the air gap d**2** existing between the second lens element **120** and the third lens element **130**, the air gap d**3** existing between the third lens element **130** and the fourth lens element **140**, the air gap d**4** existing between the fourth lens element **140** and the fifth lens element **150**, the air gap d5 existing between the fifth lens element **150** and the sixth lens element **160**, the air gap d6 existing between the sixth lens element **160** and the filtering unit **170** and the air gap d7 existing between the filtering unit **170** and the image plane **180** of the image sensor. However, in other embodiments, any of the aforesaid air gaps may or may not exist. For example, the profiles of opposite surfaces of any two adjacent lens elements may correspond to each other, and in such situation, the air gap may not exist. The air gap d**1** is denoted by G12, the air gap d**2** is denoted by G23, the air gap d**3** is denoted by G34, the air gap d**4** is denoted by G45, the air gap d**5** is denoted by G56 and the sum of d**1**, d**2**, d**3**, d**4** and d**5** is denoted by AAG.

FIG. **8** depicts the optical characteristics of each lens elements in the optical imaging lens **1** of the present embodiment, and please refer to FIGS. **62** (A) and **62**(B) for the values of T1, G12, T2, G23, T3, G34, T4, G45, T5, G56, T6, BFL, EFL, ALT, AAG, EFL/(T2+T6), BFL/T4, AAG/T3, ALT/T6, EFL/AAG. BFL/(G12+G23), ALT/BFL, (T5+T6)/(G34+G45+G56), ALT+AAG. T3/(G12+G56), ALT/(G34+G56), T4/T5, AAG/T2, and T1/(G23+G56) of the present embodiment.

The distance from the object-side surface **111** of the first lens element **110** to the image plane **180** along the optical axis may be about 4.132 mm, the image height may be about 2.3 mm. The length of the optical imaging lens **1** may be shortened compared with conventional optical imaging lenses.

The aspherical surfaces may include the object-side surface **111** of the first lens element **110**, the image-side surface **112** of the first lens element **110**, the object-side surface **121** and the image-side surface **122** of the second lens element **120**, the object-side surface **131** and the image-side surface **132** of the third lens element **130**, the object-side surface **141** and the image-side surface **142** of the fourth lens element **140**, the object-side surface **151** and the image-side surface **152** of the fifth lens element **150**, the object-side surface **161** and the image-side surface **162** of the sixth lens element **160** are all defined by the following aspherical formula:

$$Z(Y) = \frac{Y^2}{R} \Bigg/ \left(1 + \sqrt{1 - (1+K)\frac{Y^2}{R^2}}\right) + \sum_{i=1}^{n} a_{2i} \times Y^{2i}$$

wherein,

R represents the radius of curvature of the surface of the lens element;

Z represents the depth of the aspherical surface (the perpendicular distance between the point of the aspherical surface at a distance Y from the optical axis and the tangent plane of the vertex on the optical axis of the aspherical surface);

Y represents the perpendicular distance between the point of the aspherical surface and the optical axis;

K represents a conic constant;

a_{2i} represents an aspherical coefficient of $2i^{th}$ level.

The values of each aspherical parameter are shown in FIG. **9**.

FIG. **7**(*a*) shows the longitudinal spherical aberration, wherein the transverse axis of FIG. **7**(*a*) defines the focus, and the lengthwise axis of FIG. **7**(*a*) defines the filed. From the vertical deviation of each curve shown in FIG. **7**(*a*), the offset of the off-axis light relative to the image point may be within about ±0.025 mm. Therefore, the first embodiment may improve the longitudinal spherical aberration with respect to different wavelengths. Furthermore, the curves of different wavelengths may be closed to each other, and this situation may represent that off-axis light with respect to these wavelengths is focused around an image point, and the aberration can be improved.

FIGS. **7**(*b*) and **7**(*c*) respectively show the astigmatism aberration in the sagittal direction and astigmatism aberration in the tangential direction, wherein the transverse axis of FIG. **7**(*b*) defines the focus, the lengthwise axis of FIG. **7**(*b*) defines the image height, the transverse axis of FIG. **7**(*c*) defines the focus, the lengthwise axis of FIG. **7**(*c*) defines the image height. Referring to FIG. **7**(*b*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.06 mm. Referring to FIG. **7**(*c*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about +0.05 mm. Therefore, the optical imaging lens **1** may indeed eliminate aberration effectively. Additionally, the three curves presenting different wavelengths may be closed to each other, and these closed curves may represent that the dispersion is improved.

Please refer to FIG. **7**(*d*), the transverse axis of FIG. **7**(*d*) defines the percentage, the lengthwise axis of FIG. **7**(*d*) defines the image height, and the image height may be about 3.085 mm. The variation of the distortion aberration may be within about ±0.7%.

Reference is now made to FIGS. **10-13**. FIG. **10** illustrates an example cross-sectional view of an optical imaging lens **2** having six lens elements of the optical imaging lens according to a second example embodiment. FIG. **11** shows example charts of longitudinal spherical aberration and other kinds of optical aberrations of the optical imaging lens **2** according to the second example embodiment. FIG. **12** shows an example table of optical data of each lens element of the optical imaging lens **2** according to the second example embodiment. FIG. **13** shows an example table of aspherical data of the optical imaging lens **2** according to the second example embodiment. The reference numbers labeled in the present embodiment are similar to those in the first embodiment for the similar elements, but here the reference numbers are initialed with **2**, for example, reference number **231** for labeling the object-side surface of the third lens element **230**, reference number **232** for labeling the image-side surface of the third lens element **230**, etc.

As shown in FIG. **10**, the optical imaging lens **2** of the present embodiment, in an order from an object side A**1** to an image side A**2** along an optical axis, may comprise an aperture stop **200**, a first lens element **210**, a second lens element **220**, a third lens element **230**, a fourth lens element **240**, a fifth lens element **250**, and a sixth lens element **260**.

The differences between the second embodiment and the first embodiment may include the radius of curvature and thickness of each lens element, the aspherical data, the back focal length, and the configuration of the concave/convex shape of the object-side surface **241** and the image-side surfaces **222**, **242**, but the configuration of the positive/negative refracting power of the first, second, third, fourth, fifth lens elements, and sixth lens element **210**, **220**, **230**, **240**, **250**, **260** and configuration of the concave/convex shape of surfaces comprising the object-side surfaces **211**, **221**, **231**, **251**, **261** facing to the object side A**1** and the image-side surfaces **212**, **232**, **252**, **262** facing to the image side A**2** may be similar to those in the first embodiment. Here, for clearly showing the drawings of the present embodiment, only the surface shapes which are different from that in the first embodiment are labeled. Specifically, the image-side surface **222** of the second lens element **220** may comprise a convex portion **2222** in a vicinity of a periphery of the second lens element **220**, and the object-side surface **241** of the fourth lens element **240** may comprise a convex portion **2412** in a vicinity of a periphery of the fourth lens element **240**, and the image-side surface **242** of the fourth lens element **240** may comprise a convex portion **2422** in the vicinity of the periphery of the fourth lens element **240**.

Please refer to FIG. **12** for the optical characteristics of each lens elements in the optical imaging lens **2** the present embodiment, and please refer to FIGS. **62** (A) and **62**(B) for the values of T1, G12, T2, G23, T3, G34, T4, G45, T5, G56, T6, BFL, EFL, ALT, AAG, EFL/(T2+T6), BFL/T4, AAG/T3, ALT/T6, EFL/AAG. BFL/(G12+G23), ALT/BFL, (T5+T6)/(G34+G45+G56), ALT+AAG. T3/(G12+G56), ALT/(G34+G56), T4/T5, AAG/T2, and T1/(G23+G56) of the present embodiment.

The distance from the object-side surface **211** of the first lens element **210** to the image plane **280** along the optical axis may be about 4.132 mm, image height may be about 2.3 mm, and the length of the length of the optical imaging lens **2** may be shortened compared with conventional optical imaging lenses.

FIG. **11**(*a*) shows the longitudinal spherical aberration. From the vertical deviation of each curve shown in FIG. **11**(*a*), the offset of the off-axis light relative to the image point may be within about ±0.02 mm. Furthermore, the three curves having different wavelengths may be closed to each other, and this situation may represent that off-axis light with respect to these wavelengths may be focused around an image point, and the aberration can be improved obviously.

FIGS. **11**(*b*) and **11**(*c*) respectively show the astigmatism aberration in the sagittal direction and astigmatism aberration in the tangential direction, Referring to FIG. **11**(*b*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.08 mm. Referring to FIG. **11**(*c*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.06 mm. Additionally, the three curves presenting different wavelengths may be closed to each other, and these closed curves may represent that the dispersion is improved.

Please refer to FIG. **11**(*d*), the variation of the distortion aberration of the optical imaging lens **2** may be within about ±0.8%.

Therefore, the optical imaging lens **2** of the present embodiment may exhibit improved characteristics in the longitudinal spherical aberration, astigmatism in the sagittal direction, astigmatism in the tangential direction, and distortion aberration. According to above illustration, the optical imaging lens **2** of the example embodiment may indeed achieve improved optical performance and the length of the optical imaging lens **2** may be effectively shortened.

Reference is now made to FIGS. **14-17**. FIG. **14** illustrates an example cross-sectional view of an optical imaging lens **3** having six lens elements of the optical imaging lens according to a third example embodiment. FIG. **15** shows example charts of longitudinal spherical aberration and other kinds of optical aberrations of the optical imaging lens **3** according to the third example embodiment. FIG. **16** shows an example table of optical data of each lens element of the optical imaging lens **3** according to the third example embodiment. FIG. **17** shows an example table of aspherical data of the optical imaging lens **3** according to the third example embodiment. The reference numbers labeled in the present embodiment are similar to those in the first embodiment for the similar elements, but here the reference numbers are initialed with **3**, for example, reference number **331** for labeling the object-side surface of the third lens element **330**, reference number **332** for labeling the image-side surface of the third lens element **330**, etc.

As shown in FIG. **14**, the optical imaging lens **3** of the present embodiment, in an order from an object side A**1** to an image side A**2** along an optical axis, may comprise an aperture stop **300**, a first lens element **310**, a second lens element **320**, a third lens element **330**, a fourth lens element **340**, a fifth lens element **350**, and a sixth lens element **360**.

The differences between the third embodiment and the first embodiment may include the radius of curvature and thickness of each lens element, the aspherical data, the back focal length, the configuration of the positive/negative refracting power of the fifth lens element **350** and the configuration of the concave/convex shape of surfaces comprising the image-side surface **322**, **342**, but the configuration of the positive/negative refracting power of the first, second, third, fourth, and sixth lens element **310**, **320**, **330**, **340**, **350**, **360** and configuration of the concave/convex shape of surfaces comprising the object-side surfaces **311**, **321**, **331**, **341**, **351**, **361** facing to the object side A**1** and the image-side surfaces **312**, **332**, **352**, **362** facing to the image side A**2**, may be similar to those in the first embodiment. Here, for clearly showing the drawings of the present embodiment, only the surface shapes which are different from that in the first embodiment are labeled. Specifically, the image-side surface **322** of the second lens element **320** may comprise a convex portion **3222** in a vicinity of a periphery of the second lens element **320**; the image-side surface **342** of the fourth lens element **340** may comprise a convex portion **3422** in the vicinity of the periphery of the fourth lens element **340**; the fifth lens element **350** may have positive refracting power.

FIG. **16** depicts the optical characteristics of each lens elements in the optical imaging lens **3** of the present embodiment, and please refer to FIGS. **62** (A) and **62**(B) for the values of T1, G12, T2, G23, T3, G34, T4, G45, T5, G56, T6, BFL, EFL, ALT, AAG, EFL/(T2+T6), BFL/T4, AAG/T3, ALT/T6, EFL/AAG. BFL/(G12+G23), ALT/BFL, (T5+T6)/(G34+G45+G56), ALT+AAG. T3/(G12+G56), ALT/(G34+G56), T4/T5, AAG/T2, and T1/(G23+G56) of the present embodiment.

The distance from the object-side surface **311** of the first lens element **310** to the image plane **380** along the optical axis may be about 4.804 mm, the image height may be about 2.3 mm and the length of the optical imaging lens **3** may be shortened compared with conventional optical imaging lenses.

FIG. **15**(*a*) shows the longitudinal spherical aberration. From the vertical deviation of each curve shown in FIG. **15**(*a*), the offset of the off-axis light relative to the image point may be within about ±0.016 mm. Furthermore, the three curves having different wavelengths are closed to each other, and this situation may represent that off-axis light with respect to these wavelengths is focused around an image point, and the aberration may be improved.

FIGS. **15**(*b*) and **15**(*c*) respectively show the astigmatism aberration in the sagittal direction and astigmatism aberration in the tangential direction. Referring to FIG. **15**(*b*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.04 mm. Referring to FIG. **15**(*c*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.08 mm. Additionally, the three curves presenting different wavelengths may be closed to each other, and these closed curves may represent that the dispersion is improved.

Please refer to FIG. **15**(*d*), the variation of the distortion aberration of the optical imaging lens **3** may be within about ±0.6%.

Reference is now made to FIGS. **18**-**21**. FIG. **18** illustrates an example cross-sectional view of an optical imaging lens **4** having six lens elements of the optical imaging lens according to a fourth example embodiment. FIG. **19** shows example charts of longitudinal spherical aberration and other kinds of optical aberrations of the optical imaging lens **4** according to the fourth embodiment. FIG. **20** shows an example table of optical data of each lens element of the optical imaging lens **4** according to the fourth example embodiment. FIG. **21** shows an example table of aspherical data of the optical imaging lens **4** according to the fourth example embodiment. The reference numbers labeled in the present embodiment are similar to those in the first embodiment for the similar elements, but here the reference numbers are initialed with **4**, for example, reference number **431** for labeling the object-side surface of the third lens element **430**, reference number **432** for labeling the image-side surface of the third lens element **430**, etc.

As shown in FIG. **18**, the optical imaging lens **4** of the present embodiment, in an order from an object side A**1** to an image side A**2** along an optical axis, may comprise an aperture stop **400**, a first lens element **410**, a second lens element **420**, a third lens element **430**, a fourth lens element **44**, a fifth lens element **450**, and a sixth lens element **460**.

The differences between the fourth embodiment and the first embodiment may include the radius of curvature and thickness of each lens element, the aspherical data, back focal length, the configuration of the positive/negative refracting power of the fifth lens element **450**, and the configuration of the concave/convex shape of the image-side surface **422**, but the configuration of the positive/negative refracting power of the first, second, third, fourth and sixth lens elements **410**, **420**, **430**, **440**, **460** and configuration of the concave/convex shape of surfaces, comprising the object-side surfaces **411**, **421**, **441**, **451**, **461** facing to the object side A**1** and the image-side surfaces **412**, **432**, **442**, **452**, **462** facing to the image side A**2**, may be similar to those in the first embodiment. Here, for clearly showing the drawings of the present embodiment, only the surface shapes which are different from that in the first embodiment are labeled. Specifically, the image-side surface **422** of the second lens element **420** may comprise a convex portion **4222** in a vicinity of a periphery of the second lens element **420**; the fifth lens element **450** has positive refracting power.

FIG. **20** depicts the optical characteristics of each lens elements in the optical imaging lens **4** of the present embodiment, and please refer to FIGS. **62** (A) and **62**(B) for the values of T1, G12, T2, G23, T3, G34, T4, G45, T5, G56, T6, BFL, EFL, ALT, AAG, EFL/(T2+T6), BFL/T4, AAG/T3, ALT/T6, EFL/AAG. BFL/(G12+G23), ALT/BFL, (T5+T6)/(G34+G45+G56), ALT+AAG. T3/(G12+G56), ALT/(G34+G56), T4/T5, AAG/T2, and T1/(G23+G56) of the present embodiment.

The distance from the object-side surface **411** of the first lens element **410** to the image plane **480** along the optical axis may be about 4.896 mm, image height may be about 2.3 mm, and the length of the optical imaging lens **4** may be shortened compared with conventional optical imaging lenses.

FIG. **19**(*a*) shows the longitudinal spherical aberration. From the vertical deviation of each curve shown in FIG. **19**(*a*), the offset of the off-axis light relative to the image point may be within about ±0.016 mm. Furthermore, the three curves having different wavelengths may be closed to each other, and this situation may represent that off-axis light with respect to these wavelengths is focused around an image point, and the aberration can be improved.

FIGS. **19**(*b*) and **19**(*c*) respectively show the astigmatism aberration in the sagittal direction and astigmatism aberration in the tangential direction. Referring to FIG. **19**(*b*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.04 mm. Referring to FIG. **19**(*c*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.08 mm. Additionally, the three curves presenting different wavelengths may be closed to each other, and these closed curves represents that the dispersion is improved.

Please refer to FIG. **19**(*d*), the variation of the distortion aberration of the optical imaging lens **4** may be within about ±0.7%.

Reference is now made to FIGS. **22**-**25**. FIG. **22** illustrates an example cross-sectional view of an optical imaging lens **5** having six lens elements of the optical imaging lens according to a fifth example embodiment. FIG. **23** shows example charts of longitudinal spherical aberration and other kinds of optical aberrations of the optical imaging lens **5** according to the fifth embodiment. FIG. **24** shows an example table of optical data of each lens element of the optical imaging lens **5** according to the fifth example embodiment. FIG. **25** shows an example table of aspherical data of the optical imaging lens **5** according to the fifth example embodiment. The reference numbers labeled in the present embodiment are similar to those in the first embodiment for the similar elements, but here the reference numbers are initialed with **5**, for example, reference number **531** for labeling the object-side surface of the third lens element **530**, reference number **532** for labeling the image-side surface of the third lens element **530**, etc.

As shown in FIG. **22**, the optical imaging lens **5** of the present embodiment, in an order from an object side A**1** to an image side A**2** along an optical axis, may comprise an aperture stop **500**, a first lens element **510**, a second lens element **520**, a third lens element **530**, a fourth lens element **540**, a fifth lens element **550**, and a sixth lens element **560**.

The differences between the fifth embodiment and the first embodiment may include the radius of curvature and thickness of each lens element, the aspherical data, and back focal length, the configuration of the positive/negative refracting power of the fifth lens element **550**, and configuration of the concave/convex shape of the image-side surface **522**. But the configuration of the positive/negative refracting power of the first, second, third, fourth and sixth lens elements **510**, **520**, **530**, **540**, **560** and configuration of the concave/convex shape of surfaces comprising the object-side surfaces **511**, **521**, **531**, **541**, **551**, **561** facing to the object side A**1** and the image-side surfaces **512**, **532**, **542**, **552**, **562** facing to the image side A**2**, may be similar to those in the first embodiment. Here, for clearly showing the drawings of the present embodiment, only the surface shapes which are different from that in the first embodiment are labeled. Specifically, the image-side surface **522** of the second lens element **520** comprises a convex portion **5222** in a vicinity of a periphery of the second lens element **520**; the fifth lens element **550** has positive refracting power.

FIG. **24** depicts the optical characteristics of each lens elements in the optical imaging lens **5** of the present embodiment, and please refer to FIGS. **62** (A) and **62**(B) for the values of T1, G12, T2, G23, T3, G34, T4, G45, T5, G56, T6, BFL, EFL, ALT, AAG, EFL/(T2+T6), BFL/T4, AAG/T3, ALT/T6, EFL/AAG. BFL/(G12+G23), ALT/BFL, (T5+T6)/(G34+G45+G56), ALT+AAG. T3/(G12+G56), ALT/(G34+G56), T4/T5, AAG/T2, and T1/(G23+G56) of the present embodiment.

The distance from the object-side surface **511** of the first lens element **510** to the image plane **580** along the optical axis may be about 4.955 mm, the image height may be about 2.3 mm, and the length of the optical imaging lens **5** may be shortened compared with conventional optical imaging lenses and even with the optical imaging lens **5** of the first embodiment. Thus, the optical imaging lens **5** may be capable of providing excellent imaging quality for smaller sized mobile devices.

FIG. **23**(*a*) shows the longitudinal spherical aberration of the first embodiment. From the vertical deviation of each curve shown in FIG. **23**(*a*), the offset of the off-axis light relative to the image point may be within about ±0.01 mm. Furthermore, the three curves having different wavelengths may be closed to each other, and this situation may represent that off-axis light with respect to these wavelengths is focused around an image point, and the aberration can be improved obviously.

FIGS. **23**(*b*) and **23**(*c*) respectively show the astigmatism aberration in the sagittal direction and astigmatism aberration in the tangential direction. Referring to FIG. **23**(*b*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.04 mm. Referring to FIG. **23**(*c*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.08 mm. Additionally, the three curves presenting different wavelengths may be closed to each other, and these closed curves may represent that the dispersion is improved.

Please refer to FIG. **23**(*d*), the variation of the distortion aberration of the optical imaging lens **5** may be within about ±0.8%.

Reference is now made to FIGS. **26-29**. FIG. **26** illustrates an example cross-sectional view of an optical imaging lens **6** having six lens elements of the optical imaging lens according to a sixth example embodiment. FIG. **27** shows example charts of longitudinal spherical aberration and other kinds of optical aberrations of the optical imaging lens **6** according to the sixth embodiment. FIG. **28** shows an example table of optical data of each lens element of the optical imaging lens **6** according to the sixth example embodiment. FIG. **29** shows an example table of aspherical data of the optical imaging lens **6** according to the sixth example embodiment. The reference numbers labeled in the present embodiment are similar to those in the first embodiment for the similar elements, but here the reference numbers are initialed with **6**, for example, reference number **631** for labeling the object-side surface of the third lens element **630**, reference number **632** for labeling the image-side surface of the third lens element **630**, etc.

As shown in FIG. **26**, the optical imaging lens **6** of the present embodiment, in an order from an object side A**1** to an image side A**2** along an optical axis, may comprise an aperture stop **600**, a first lens element **610**, a second lens element **620**, a third lens element **630**, a fourth lens element **640**, a fifth lens element **650** and a sixth lens element **660**. The differences between the sixth embodiment and the first embodiment may include the radius of curvature and thickness of each lens element, the aspherical data, back focal length, and the configuration of the concave/convex shape of the object-side surface **661** and the image-side surfaces **622**, **642**, but the configuration of the positive/negative refracting power of the first, second, third, fourth, fifth, and sixth lens elements **610**, **620**, **630**, **640**, **650**, **660** and configuration of the concave/convex shape of surfaces, comprising the object-side surfaces **611**, **621**, **631**, **641**, **651** facing to the object side A**1** and the image-side surfaces **612**, **632**, **642**, **652**, **662** facing to the image side A**2**, may be similar to those in the first embodiment. Here, for clearly showing the drawings of the present embodiment, only the surface shapes which are different from that in the first embodiment are labeled. Specifically, the image-side surface **622** of the second lens element **620** may comprise a convex portion **6222** in a vicinity of a periphery of the second lens element **620**, the image-side surface **642** of the fourth lens element **640** may comprise a convex portion **6422** in the vicinity of a periphery of the fourth lens element **640**, and the object-side surface **661** of the sixth lens element **660** may comprise a convex portion **6612** in the vicinity of a periphery of the sixth lens element **660**.

FIG. **28** depicts the optical characteristics of each lens elements in the optical imaging lens **6** of the present embodiment, and please refer to FIGS. **62** (A) and **62**(B) for the values of T1, G12, T2, G23, T3, G34, T4, G45, T5, G56, T6, BFL, EFL, ALT, AAG, EFL/(T2+T6), BFL/T4, AAG/T3, ALT/T6, EFL/AAG. BFL/(G12+G23), ALT/BFL, (T5+T6)/(G34+G45+G56), ALT+AAG. T3/(G12+G56), ALT/(G34+G56), T4/T5, AAG/T2, and T1/(G23+G56) of the present embodiment.

The distance from the object-side surface **611** of the first lens element **610** to the image plane **680** along the optical axis may be about 5.384 mm, the image height may be about 3.0 mm, and the length of the optical imaging lens **6** may be shortened compared with conventional optical imaging lenses. Thus, the optical imaging lens **6** may be capable of providing excellent imaging quality for smaller sized mobile devices.

FIG. **27**(*a*) shows the longitudinal spherical aberration. From the vertical deviation of each curve shown in FIG. **27**(*a*), the offset of the off-axis light relative to the image point may be within about ±0.018 mm. Furthermore, the three curves having different wavelengths may be closed to each other, and this situation may represent that off-axis light with respect to these wavelengths is focused around an image point, and the aberration can be improved obviously.

FIGS. **27**(*b*) and **27**(*c*) respectively show the astigmatism aberration in the sagittal direction and astigmatism aberration in the tangential direction. Referring to FIG. **27**(*b*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.06 mm. Referring to FIG. **23**(*c*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.08 mm. Additionally, the three curves presenting different wavelengths may be closed to each other, and these closed curves may represent that the dispersion is improved.

Please refer to FIG. **27**(*d*), the variation of the distortion aberration of the optical imaging lens **6** may be within about ±2%.

Reference is now made to FIGS. **30-33**. FIG. **30** illustrates an example cross-sectional view of an optical imaging lens **7** having six lens elements of the optical imaging lens according to a seventh example embodiment. FIG. **31** shows example charts of longitudinal spherical aberration and other kinds of optical aberrations of the optical imaging lens **7** according to the seventh embodiment. FIG. **32** shows an example table of optical data of each lens element of the optical imaging lens **7** according to the seventh example embodiment. FIG. **33** shows an example table of aspherical data of the optical imaging lens **7** according to the seventh example embodiment. The reference numbers labeled in the present embodiment are similar to those in the first embodiment for the similar elements, but here the reference numbers are initialed with **7**, for example, reference number **731** for labeling the object-side surface of the third lens element **730**, reference number **732** for labeling the image-side surface of the third lens element **730**, etc.

As shown in FIG. **30**, the optical imaging lens **7** of the present embodiment, in an order from an object side **A1** to an image side **A2** along an optical axis, may comprise an aperture stop **700**, a first lens element **710**, a second lens element **720**, a third lens element **730**, a fourth lens element **740**, a fifth lens element **750**, and a sixth lens element **760**.

The differences between the seventh embodiment and the first embodiment may include the radius of curvature, thickness of each lens element, the aspherical data, back focal length, and the configuration of the concave/convex shape of the object-side surface **731** and the image-side surfaces **722**, **742** but the configuration of the positive/negative refracting power of the first, second, third, fourth, fifth and sixth lens elements **710**, **720**, **730**, **740**, **750**, **760** and configuration of the concave/convex shape of surfaces, comprising the object-side surfaces **711**, **721**, **741**, **751**, **761** facing to the object side **A1** and the image-side surfaces **712**, **732**, **752**, **762** facing to the image side **A2**, may be similar to those in the first embodiment. Here, for clearly showing the drawings of the present embodiment, only the surface shapes which are different from that in the first embodiment are labeled. Specifically, the image-side surface **722** of the second lens element **720** may comprise a convex portion **7222** in a vicinity of a periphery of the second lens element **720**; the object-side surface **731** of the third lens element **730** may comprise a concave portion **7311** in a vicinity of the optical axis; and the image-side surface **742** of the fourth lens element **740** may comprise a convex portion **7422** in a vicinity of a periphery of the fourth lens element **740**.

FIG. **32** depicts the optical characteristics of each lens elements in the optical imaging lens **1** of the present embodiment, and please refer to FIGS. **62** (A) and **62**(B) for the values of T1, G12, T2, G23, T3, G34, T4, G45, T5, G56, T6, BFL, EFL, ALT, AAG, EFL/(T2+T6), BFL/T4, AAG/T3, ALT/T6, EFL/AAG. BFL/(G12+G23), ALT/BFL, (T5+T6)/(G34+G45+G56), ALT+AAG. T3/(G12+G56), ALT/(G34+G56), T4/T5, AAG/T2, and T1/(G23+G56) of the present embodiment.

The distance from the object-side surface **711** of the first lens element **710** to the image plane **780** along the optical axis may be about 3.782 mm, the image height may be about 2.3 mm, and the length of the optical imaging lens **7** may be shortened compared with conventional optical imaging lenses.

FIG. **31**(*a*) shows the longitudinal spherical aberration. From the vertical deviation of each curve shown in FIG. **31**(*a*), the offset of the off-axis light relative to the image point may be within about ±0.07 mm. Furthermore, the three curves having different wavelengths may be closed to each other, and this situation may represent that off-axis light with respect to these wavelengths is focused around an image point, and the aberration can be improved obviously.

FIGS. **31**(*b*) and **31**(*c*) respectively show the astigmatism aberration in the sagittal direction and astigmatism aberration in the tangential direction. Referring to FIG. **31**(*b*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about +0.1 mm. Referring to FIG. **31**(*c*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.08 mm. Additionally, the three curves presenting different wavelengths may be closed to each other, and these closed curves may represent that the dispersion is improved.

Please refer to FIG. **31**(*d*), the variation of the distortion aberration of the optical imaging lens **7** may be within about ±2.0%.

Reference is now made to FIGS. **34**-**37**. FIG. **34** illustrates an example cross-sectional view of an optical imaging lens **8** having six lens elements of the optical imaging lens according to an eighth example embodiment. FIG. **35** shows example charts of longitudinal spherical aberration and other kinds of optical aberrations of the optical imaging lens **8** according to the eighth embodiment. FIG. **36** shows an example table of optical data of each lens element of the optical imaging lens **8** according to the eighth example embodiment. FIG. **37** shows an example table of aspherical data of the optical imaging lens **8** according to the eighth example embodiment. The reference numbers labeled in the present embodiment are similar to those in the first embodiment for the similar elements, but here the reference numbers are initialed with **8**, for example, reference number **831** for labeling the object-side surface of the third lens element **830**, reference number **832** for labeling the image-side surface of the third lens element **830**, etc.

As shown in FIG. **34**, the optical imaging lens **8** of the present embodiment, in an order from an object side **A1** to an image side **A2** along an optical axis, may comprise an aperture stop **800**, a first lens element **810**, a second lens element **820**, a third lens element **830**, a fourth lens element **840**, a fifth lens element **850**, and a sixth lens element **860**.

The differences between the eighth embodiment and the first embodiment may include the radius of curvature and thickness of each lens element, the aspherical data, back focal length, the configuration of the positive/negative refracting power of the sixth lens element **860**, and the configuration of the concave/convex shape of the object-side surface **831** and image-side surfaces **822**, **842**, but the configuration of the positive/negative refracting power of the first, second, third, fourth, and fifth lens elements **810**, **820**, **830**, **840**, **850** and configuration of the concave/convex shape of surfaces, comprising the object-side surfaces **811**, **821**, **841**, **851**, **861** facing to the object side **A1** and the image-side surfaces **812**, **832**, **852**, **862** facing to the image side **A2**, may be similar to those in the first embodiment. Here, for clearly showing the drawings of the present embodiment, only the surface shapes which are different from that in the first embodiment are labeled. Specifically, the image-side surface **822** of the second lens element **820** may comprise a convex portion **8222** in a vicinity of a periphery of the second lens element **820**; the object-side surface **831** of the third lens element **830** may comprise a concave portion **8311** in a vicinity of the optical axis; the image-side surface **842** of the fourth lens element **840** may comprise a convex portion **8422** in the vicinity of a periphery of the fourth lens element **840**, and the sixth lens element **860** may have positive refracting power.

FIG. **36** depicts the optical characteristics of each lens elements in the optical imaging lens **8** of the present embodiment, and please refer to FIGS. **62** (A) and **62**(B) for the values of T1, G12, T2, G23, T3, G34, T4, G45, T5, G56, T6, BFL, EFL, ALT, AAG, EFL/(T2+T6), BFL/T4, AAG/T3, ALT/T6, EFL/AAG. BFL/(G12+G23), ALT/BFL, (T5+T6)/(G34+G45+G56), ALT+AAG. T3/(G12+G56), ALT/(G34+G56), T4/T5, AAG/T2, and T1/(G23+G56) of the present embodiment.

The distance from the object-side surface **811** of the first lens element **810** to the image plane **880** along the optical axis may be about 3.840 mm, the image height may be about 2.3 mm, and the length of the optical imaging lens **8** may be shortened compared with conventional optical imaging lenses. Thus, the optical imaging lens **8** may be capable of providing excellent imaging quality for smaller sized mobile devices.

FIG. **35**(*a*) shows the longitudinal spherical aberration. From the vertical deviation of each curve shown in FIG. **35**(*a*), the offset of the off-axis light relative to the image point may be within about ±0.06 mm. Furthermore, the three curves having different wavelengths may be closed to each other, and this situation may represent that off-axis light with respect to these wavelengths is focused around an image point, and the aberration may be improved.

FIGS. **35**(*b*) and **35**(*c*) respectively show the astigmatism aberration in the sagittal direction and astigmatism aberration in the tangential direction. Referring to FIG. **35**(*b*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.18 mm. Referring to FIG. **35**(*c*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.16 mm. Additionally, the three curves presenting different wavelengths may be closed to each other, and these closed curves may represent that the dispersion is improved.

Please refer to FIG. **35**(*d*), the variation of the distortion aberration of the optical imaging lens **8** may be within about ±1.8%.

Reference is now made to FIGS. **38**-**41**. FIG. **38** illustrates an example cross-sectional view of an optical imaging lens **9** having six lens elements of the optical imaging lens according to a ninth example embodiment. FIG. **39** shows example charts of longitudinal spherical aberration and other kinds of optical aberrations of the optical imaging lens **9** according to the ninth embodiment. FIG. **40** shows an example table of optical data of each lens element of the optical imaging lens **9** according to the ninth example embodiment. FIG. **41** shows an example table of aspherical data of the optical imaging lens **9** according to the ninth example embodiment. The reference numbers labeled in the present embodiment are similar to those in the first embodiment for the similar elements, but here the reference numbers are initialed with **9**, for example, reference number **931** for labeling the object-side surface of the third lens element **930**, reference number **932** for labeling the image-side surface of the third lens element **930**, etc.

As shown in FIG. **38**, the optical imaging lens **9** of the present embodiment, in an order from an object side A**1** to an image side A**2** along an optical axis, may comprise an aperture stop **900**, a first lens element **910**, a second lens element **920**, a third lens element **930**, a fourth lens element **940**, a fifth lens element **950**, and a sixth lens element **960**.

The differences between the ninth embodiment and the first embodiment are the radius of curvature and thickness of each lens element, the aspherical data, back focal length, and the configuration of the concave/convex shape of the object-side surface **931** and image-side surfaces **922**, **942**, but the configuration of the positive/negative refracting power of the first, second, third, fourth, fifth, and sixth lens elements **910**, **920**, **930**, **940**, **950**, **960** and configuration of the concave/convex shape of surfaces, comprising the object-side surfaces **911**, **921**, **941**, **951**, **961** facing to the object side A**1** and the image-side surfaces **912**, **932**, **952**, **962** facing to the image side A**2**, may be similar to those in the first embodiment. Here, for clearly showing the drawings of the present embodiment, only the surface shapes which are different from that in the first embodiment are labeled. Specifically, the image-side surface **922** of the second lens element **920** may comprise a convex portion **9222** in a vicinity of a periphery of the second lens element **920**; the object-side surface **931** of the third lens element **930** may comprise a concave portion **9311** in a vicinity of the optical axis; and the image-side surface **942** of the fourth lens element **940** may comprise a convex portion **9422** in a vicinity of a periphery of the fourth lens element **940**.

FIG. **40** depicts the optical characteristics of each lens elements in the optical imaging lens **9** of the present embodiment, and please refer to FIGS. **62** (A) and **62**(B) for the values of T1, G12, T2, G23, T3, G34, T4, G45, T5, G56, T6, BFL, EFL, ALT, AAG, EFL/(T2+T6), BFL/T4, AAG/T3, ALT/T6, EFL/AAG. BFL/(G12+G23), ALT/BFL, (T5+T6)/(G34+G45+G56), ALT+AAG. T3/(G12+G56), ALT/(G34+G56), T4/T5, AAG/T2, and T1/(G23+G56) of the present embodiment.

The distance from the object-side surface **911** of the first lens element **910** to the image plane **980** along the optical axis may be about 3.862 mm, the image height may be about 2.3 mm, and the length of the optical imaging lens **9** may be shortened compared with conventional optical imaging lenses. Thus, the optical imaging lens **9** may be capable of providing excellent imaging quality for smaller sized mobile devices.

FIG. **39**(*a*) shows the longitudinal spherical aberration. From the vertical deviation of each curve shown in FIG. **39**(*a*), the offset of the off-axis light relative to the image point may be within about ±0.07 mm. Furthermore, the three curves having different wavelengths may be closed to each other, and this situation may represent that off-axis light with respect to these wavelengths is focused around an image point, and the aberration can be improved.

FIGS. **39**(*b*) and **39**(*c*) respectively show the astigmatism aberration in the sagittal direction and astigmatism aberration in the tangential direction. Referring to FIG. **39**(*b*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.16 mm. Referring to FIG. **39**(*c*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.16 mm. Additionally, the three curves presenting different wavelengths may be closed to each other, and these closed curves may represent that the dispersion is improved.

Please refer to FIG. **39**(*d*), the variation of the distortion aberration of the optical imaging lens **9** may be within about ±2.0%.

Reference is now made to FIGS. **42**-**45**. FIG. **42** illustrates an example cross-sectional view of an optical imaging lens **10** having six lens elements of the optical imaging lens according to a tenth example embodiment. FIG. **43** shows example charts of longitudinal spherical aberration and other kinds of optical aberrations of the optical imaging lens **10** according to the tenth embodiment. FIG. **44** shows an example table of optical data of each lens element of the optical imaging lens **10** according to the tenth example embodiment. FIG. **45** shows an example table of aspherical data of the optical imaging lens **10** according to the tenth example embodiment. The reference numbers labeled in the present embodiment are similar to those in the first embodiment for the similar elements, but here the reference numbers are initialed with **10**, for example, reference number **1031** for labeling the object-side surface of the third lens element **1030**, reference number **1032** for labeling the image-side surface of the third lens element **1030**, etc.

As shown in FIG. **42**, the optical imaging lens **10** of the present embodiment, in an order from an object side A**1** to an image side A**2** along an optical axis, may comprise an aperture stop **1000**, a first lens element **1010**, a second lens element **1020**, a third lens element **1030**, a fourth lens element **1040**, a fifth lens element **1050**, and a sixth lens element **1060**.

The differences between the tenth embodiment and the first embodiment may include the radius of curvature and thickness of each lens element, the aspherical data, back focal length, the configuration of the positive/negative refracting power of the sixth lens element **1060**, and the configuration of the concave/convex shape of the object-side surface **1031** and image-side surfaces **1022**, **1042**, but the configuration of the positive/negative refracting power of the first, second, third, fourth, and fifth lens elements **1010**, **1020**, **1030**, **1040**, **1050** and configuration of the concave/convex shape of surfaces, comprising the object-side surfaces **1011**, **1021**, **1041**, **1051**, **1061** facing to the object side A**1** and the image-side surfaces **1012**, **1032**, **1052**, **1062** facing to the image side A**2**, may be similar to those in the first embodiment. Here, for clearly showing the drawings of the present embodiment, only the surface shapes which are different from that in the first embodiment are labeled. Specifically, the image-side surface **1022** of the second lens element **1020** may comprise a convex portion **10222** in a vicinity of a periphery of the second lens element **1020**; the object-side surface **1031** of the third lens element **1030** may comprise a concave portion **10311** in a vicinity of the optical axis; the image-side surface **1042** of the fourth lens element **1040** may comprise a convex portion **10422** in a vicinity of a periphery of the fourth lens element **1040**; and the sixth lens element **1060** may have positive refracting power.

FIG. **44** depicts the optical characteristics of each lens elements in the optical imaging lens **10** of the present embodiment, and please refer to FIGS. **62** (A) and **62**(B) for the values of T1, G12, T2, G23, T3, G34, T4, G45, T5, G56, T6, BFL, EFL, ALT, AAG, EFL/(T2+T6), BFL/T4, AAG/T3, ALT/T6, EFL/AAG. BFL/(G12+G23), ALT/BFL, (T5+T6)/(G34+G45+G56), ALT+AAG. T3/(G12+G56), ALT/(G34+G56), T4/T5, AAG/T2, and T1/(G23+G56) of the present embodiment.

The distance from the object-side surface **1011** of the first lens element **1010** to the image plane **1080** along the optical axis may be about 3.866 mm, the image height may be about 2.3 mm, and the length of the optical imaging lens **10** may be shortened compared with conventional optical imaging lenses. Thus, the optical imaging lens **10** may be capable of providing excellent imaging quality for smaller sized mobile devices.

FIG. **43**(*a*) shows the longitudinal spherical aberration. From the vertical deviation of each curve shown in FIG. **43**(*a*), the offset of the off-axis light relative to the image point may be within about ±0.018 mm. Furthermore, the three curves having different wavelengths may be closed to each other, and this situation may represent that off-axis light with respect to these wavelengths is focused around an image point, and the aberration can be improved obviously.

FIGS. **43**(*b*) and **43**(*c*) respectively show the astigmatism aberration in the sagittal direction and astigmatism aberration in the tangential direction. Referring to FIG. **43**(*b*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.18 mm. Referring to FIG. **43**(*c*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.16 mm. Additionally, the three curves presenting different wavelengths may be closed to each other, and these closed curves may represent that the dispersion is improved.

Please refer to FIG. **43**(*d*), the variation of the distortion aberration of the optical imaging lens **10** may be within about ±3.0%.

Reference is now made to FIGS. **46**-**49**. FIG. **46** illustrates an example cross-sectional view of an optical imaging lens **11** having six lens elements of the optical imaging lens according to a eleventh example embodiment. FIG. **47** shows example charts of longitudinal spherical aberration and other kinds of optical aberrations of the optical imaging lens **11** according to the eleventh embodiment. FIG. **48** shows an example table of optical data of each lens element of the optical imaging lens **11** according to the eleventh example embodiment. FIG. **49** shows an example table of aspherical data of the optical imaging lens **11** according to the eleventh example embodiment. The reference numbers labeled in the present embodiment are similar to those in the first embodiment for the similar elements, but here the reference numbers are initialed with **11**, for example, reference number **1131** for labeling the object-side surface of the third lens element **1130**, reference number **1132** for labeling the image-side surface of the third lens element **1130**, etc.

As shown in FIG. **46**, the optical imaging lens **11** of the present embodiment, in an order from an object side A**1** to an image side A**2** along an optical axis, may comprise an aperture stop **1100**, a first lens element **1110**, a second lens element **1120**, a third lens element **1130**, a fourth lens element **1140**, a fifth lens element **1150** and a sixth lens element **1160**.

The differences between the eleventh embodiment and the first embodiment may include the radius of curvature and thickness of each lens element, the aspherical data, back focal length, and the configuration of the concave/convex shape of the object-side surface **1131** and image-side surfaces **1122**, **1142**, but the configuration of the positive/negative refracting power of the first, second, third, fourth, fifth, and sixth lens elements **1110**, **1120**, **1130**, **1140**, **1150**, **1160** and configuration of the concave/convex shape of surfaces, comprising the object-side surfaces **1111**, **1121**, **1141**, **1151**, **1161** facing to the object side A**1** and the image-side surfaces **1112**, **1132**, **1152**, **1162** facing to the image side A**2**, may be similar to those in the first embodiment. Here, for clearly showing the drawings of the present embodiment, only the surface shapes which are different from that in the first embodiment are labeled. Specifically, the image-side surface **1122** of the second lens element **1120** may comprise a convex portion **11222** in a vicinity of a periphery of the second lens element **1120**; the object-side surface **1131** of the third lens element **1130** may comprise a concave portion **11311** in a vicinity of a optical axis of the third lens element **1130**; and the image-side surface **1142** of the fourth lens element **1140** may comprise a convex portion **11422** in a vicinity of a periphery of the fourth lens element **1140**.

FIG. **48** depicts the optical characteristics of each lens elements in the optical imaging lens **11** of the present embodiment, and please refer to FIGS. **62** (A) and **62**(B) for the values of T1, G12, T2, G23, T3, G34, T4, G45, T5, G56, T6, BFL, EFL, ALT, AAG, EFL/(T2+T6), BFL/T4, AAG/T3, ALT/T6, EFL/AAG. BFL/(G12+G23), ALT/BFL, (T5+T6)/(G34+G45+G56), ALT+AAG. T3/(G12+G56), ALT/(G34+G56), T4/T5, AAG/T2, and T1/(G23+G56) of the present embodiment.

The distance from the object-side surface **1111** of the first lens element **1110** to the image plane **1180** along the optical axis may be about 3.800 mm, the image height may be about 2.3 mm, and the length of the optical imaging lens **11** may be shortened compared with conventional optical imaging lenses. Thus, the optical imaging lens **11** may be capable of providing excellent imaging quality for smaller sized mobile devices.

FIG. **47**(*a*) shows the longitudinal spherical aberration. From the vertical deviation of each curve shown in FIG. **47**(*a*), the offset of the off-axis light relative to the image point may be within about ±0.07 mm. Furthermore, the three curves having different wavelengths may be closed to each other, and this situation may represent that off-axis light with respect to these wavelengths is focused around an image point, and the aberration can be improved.

FIGS. **47**(*b*) and **47**(*c*) respectively show the astigmatism aberration in the sagittal direction and astigmatism aberration in the tangential direction. Referring to FIG. **47**(*b*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.18 mm. Referring to FIG. **47**(*c*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.18 mm. Additionally, the three curves presenting different wavelengths may be closed to each other, and these closed curves may represent that the dispersion is improved.

Please refer to FIG. **47**(*d*), the variation of the distortion aberration of the optical imaging lens **11** may be within about ±1.8%.

Reference is now made to FIGS. **50-53**. FIG. **50** illustrates an example cross-sectional view of an optical imaging lens **12** having six lens elements of the optical imaging lens according to a twelfth example embodiment. FIG. **51** shows example charts of longitudinal spherical aberration and other kinds of optical aberrations of the optical imaging lens **12** according to the twelfth embodiment. FIG. **52** shows an example table of optical data of each lens element of the optical imaging lens **12** according to the twelfth example embodiment. FIG. **53** shows an example table of aspherical data of the optical imaging lens **12** according to the twelfth example embodiment. The reference numbers labeled in the present embodiment are similar to those in the first embodiment for the similar elements, but here the reference numbers are initialed with **12**, for example, reference number **1231** for labeling the object-side surface of the third lens element **1230**, reference number **1232** for labeling the image-side surface of the third lens element **1230**, etc.

As shown in FIG. **50**, the optical imaging lens **12** of the present embodiment, in an order from an object side A**1** to an image side A**2** along an optical axis, may comprise an aperture stop **1200**, a first lens element **1210**, a second lens element **1220**, a third lens element **1230**, a fourth lens element **1240**, a fifth lens element **1250** and a sixth lens element **1260**.

The differences between the twelfth embodiment and the first embodiment may include the radius of curvature and thickness of each lens element, the aspherical data, back focal length, the configuration of the positive/negative refracting power of the sixth lens element **1260**, and the configuration of the concave/convex shape of the object-side surface **1231** and image-side surfaces **1222**, **1242**, but the configuration of the positive/negative refracting power of the first, second, third, fourth, and fifth lens elements **1210**, **1220**, **1230**, **1240**, **1250** and configuration of the concave/convex shape of surfaces, comprising the object-side surfaces **1211**, **1221**, **1241**, **1251**, **1261** facing to the object side A**1** and the image-side surfaces **1212**, **1232**, **1252**, **1262** facing to the image side A**2**, may be similar to those in the first embodiment. Here, for clearly showing the drawings of the present embodiment, only the surface shapes which are different from that in the first embodiment are labeled. Specifically, the image-side surface **1222** of the second lens element **1220** may comprise a convex portion **12222** in a vicinity of a periphery of the second lens element **1220**; the object-side surface **1231** of the third lens element **1230** may comprise a concave portion **12311** in a vicinity of the optical axis; the image-side surface **1242** of the fourth lens element **1240** may comprise a convex portion **12422** in a vicinity of a periphery of the fourth lens element **1240**; and the sixth lens element **1260** may have positive refracting power.

FIG. **52** depicts the optical characteristics of each lens elements in the optical imaging lens **12** of the present embodiment, and please refer to FIGS. **62** (A) and **62**(B) for the values of T1, G12, T2, G23, T3, G34, T4, G45, T5, G56, T6, BFL, EFL, ALT, AAG, EFL/(T2+T6), BFL/T4, AAG/T3, ALT/T6, EFL/AAG. BFL/(G12+G23), ALT/BFL, (T5+T6)/(G34+G45+G56), ALT+AAG. T3/(G12+G56), ALT/(G34+G56), T4/T5, AAG/T2, and T1/(G23+G56) of the present embodiment.

The distance from the object-side surface **1211** of the first lens element **1210** to the image plane **1280** along the optical axis may be about 3.787 mm, the image height may be about 2.3 mm, and the length of the optical imaging lens **12** may be shortened compared with conventional optical imaging lenses. Thus, the optical imaging lens **12** may be capable of providing excellent imaging quality for smaller sized mobile devices.

FIG. **51**(*a*) shows the longitudinal spherical aberration. From the vertical deviation of each curve shown in FIG. **51**(*a*), the offset of the off-axis light relative to the image point may be within about ±0.035 mm. Furthermore, the three curves having different wavelengths may be closed to each other, and this situation may represent that off-axis light with respect to these wavelengths is focused around an image point, and the aberration can be improved.

FIGS. **51**(*b*) and **51**(*c*) respectively show the astigmatism aberration in the sagittal direction and astigmatism aberration in the tangential direction. Referring to FIG. **51**(*b*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.16 mm. Referring to FIG. **51**(*c*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.14 mm. Additionally, the three curves presenting different wavelengths are closed to each other, and these closed curves may represent that the dispersion is improved.

Please refer to FIG. **51**(*d*), the variation of the distortion aberration of the optical imaging lens **12** may be within about ±0.8%.

Reference is now made to FIGS. **54-57**. FIG. **54** illustrates an example cross-sectional view of an optical imaging lens **13** having six lens elements of the optical imaging lens according to a thirteenth example embodiment. FIG. **55** shows example charts of longitudinal spherical aberration and other kinds of optical aberrations of the optical imaging lens **13** according to the thirteenth embodiment. FIG. **56** shows an example table of optical data of each lens element of the optical imaging lens **13** according to the thirteenth example embodiment. FIG. **57** shows an example table of aspherical data of the optical imaging lens **13** according to the thirteenth example embodiment. The reference numbers labeled in the present embodiment are similar to those in the first embodiment for the similar elements, but here the reference numbers are initialed with **13**, for example, reference number **1331** for labeling the object-side surface of the third lens element **1330**, reference number **1332** for labeling the image-side surface of the third lens element **1330**, etc.

As shown in FIG. **54**, the optical imaging lens **13** of the present embodiment, in an order from an object side A**1** to an image side A**2** along an optical axis, may comprise an aperture stop **1300**, a first lens element **1310**, a second lens element **1320**, a third lens element **1330**, a fourth lens element **1340**, a fifth lens element **1350** and a sixth lens element **1360**.

The differences between the thirteenth embodiment and the first embodiment may include the radius of curvature and thickness of each lens element, the aspherical data, back focal length, and the configuration of the concave/convex shape of the object-side surface **1331** and image-side surfaces **1322**, **1342**, but the configuration of the positive/negative refracting power of the first, second, third, fourth, fifth and sixth lens elements **1310**, **1320**, **1330**, **1340**, **1350**, **1360** and configuration of the concave/convex shape of surfaces, comprising the object-side surfaces **1311**, **1321**, **1341**, **1351**, **1361** facing to the object side A**1** and the image-side surfaces **1312**, **1332**, **1352**, **1362** facing to the image side A**2**, may be similar to those in the first embodiment. Here, for clearly showing the drawings of the present embodiment, only the surface shapes which are different from that in the first embodiment are labeled. Specifically, the image-side surface **1322** of the second lens element **1320** may comprise a convex portion **13222** in a vicinity of a periphery of the second lens element **1320**; the object-side surface **1331** of the third lens element **1330** may comprise a concave portion **13311** in a vicinity of the optical axis; and the image-side surface **1342** of the fourth lens element **1340** may comprise a convex portion **13422** in a vicinity of a periphery of the fourth lens element **1340**.

FIG. **56** depicts the optical characteristics of each lens elements in the optical imaging lens **13** of the present embodiment, and please refer to FIGS. **62** (A) and **62**(B) for the values of T1, G12, T2, G23, T3, G34, T4, G45, T5, G56, T6, BFL, EFL, ALT, AAG, EFL/(T2+T6), BFL/T4, AAG/T3, ALT/T6, EFL/AAG. BFL/(G12+G23), ALT/BFL, (T5+T6)/(G34+G45+G56), ALT+AAG. T3/(G12+G56), ALT/(G34+G56), T4/T5, AAG/T2, and T1/(G23+G56) of the present embodiment.

The distance from the object-side surface **1311** of the first lens element **1310** to the image plane **1380** along the optical axis may be about 3.802 mm, the image height may be about 2.3 mm, and the length of the optical imaging lens **13** may be shortened compared with conventional optical imaging lenses. Thus, the optical imaging lens **13** may be capable of providing excellent imaging quality for smaller sized mobile devices.

FIG. **55**(*a*) shows the longitudinal spherical aberration. From the vertical deviation of each curve shown in FIG. **55**(*a*), the offset of the off-axis light relative to the image point may be within about ±0.06 mm. Furthermore, the three curves having different wavelengths may be closed to each other, and this situation may represent that off-axis light with respect to these wavelengths is focused around an image point, and the aberration can be improved.

FIGS. **55**(*b*) and **55**(*c*) respectively show the astigmatism aberration in the sagittal direction and astigmatism aberration in the tangential direction. Referring to FIG. **55**(*b*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.16 mm. Referring to FIG. **55**(*c*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.14 mm. Additionally, the three curves presenting different wavelengths may be closed to each other, and these closed curves may represent that the dispersion is improved.

Please refer to FIG. **55**(*d*), the variation of the distortion aberration of the optical imaging lens **13** may be within about ±2.0%.

Reference is now made to FIGS. **58**-**61**. FIG. **58** illustrates an example cross-sectional view of an optical imaging lens **14** having six lens elements of the optical imaging lens according to a fourteenth example embodiment. FIG. **59** shows example charts of longitudinal spherical aberration and other kinds of optical aberrations of the optical imaging lens **14** according to the fourteenth embodiment. FIG. **60** shows an example table of optical data of each lens element of the optical imaging lens **14** according to the fourteenth example embodiment. FIG. **61** shows an example table of aspherical data of the optical imaging lens **14** according to the fourteenth example embodiment. The reference numbers labeled in the present embodiment are similar to those in the first embodiment for the similar elements, but here the reference numbers are initialed with **14**, for example, reference number **1431** for labeling the object-side surface of the third lens element **1430**, reference number **1432** for labeling the image-side surface of the third lens element **1430**, etc.

As shown in FIG. **58**, the optical imaging lens **14** of the present embodiment, in an order from an object side A**1** to an image side A**2** along an optical axis, may comprise an aperture stop **1400**, a first lens element **1410**, a second lens element **1420**, a third lens element **1430**, a fourth lens element **1440**, a fifth lens element **1450**, and a sixth lens element **1460**.

The differences between the fourteenth embodiment and the first embodiment may include the radius of curvature and thickness of each lens element, the aspherical data, back focal length, the configuration of the positive/negative refracting power of the sixth lens element **1460**, and the configuration of the concave/convex shape of the object-side surface **1431** and image-side surfaces **1422**, **1442**, but the configuration of the positive/negative refracting power of the first, second, third, fourth, and fifth lens elements **1410**, **1420**, **1430**, **1440**, **1450** and configuration of the concave/convex shape of surfaces, comprising the object-side surfaces **1411**, **1421**, **1441**, **1451**, **1461** facing to the object side A**1** and the image-side surfaces **1412**, **1432**, **1452**, **1462** facing to the image side A**2**, may be similar to those in the first embodiment. Here, for clearly showing the drawings of the present embodiment, only the surface shapes which are different from that in the first embodiment are labeled. Specifically, the image-side surface **1422** of the second lens element **1420** comprises a convex portion **14222** in a vicinity of a periphery of the second lens element **1420**; the object-side surface **1431** of the third lens element **1430** comprises a concave portion **14311** in a vicinity of the optical axis; the image-side surface **1442** of the fourth lens element **1440** comprises a convex portion **14422** in a vicinity of a periphery of the fourth lens element **1440**; and the sixth lens element **1460** has positive refracting power.

FIG. **60** depicts the optical characteristics of each lens elements in the optical imaging lens **14** of the present embodiment, and please refer to FIGS. **62** (A) and **62**(B) for the values of T1, G12, T2, G23, T3, G34, T4, G45, T5, G56, T6, BFL, EFL, ALT, AAG, EFL/(T2+T6), BFL/T4, AAG/T3, ALT/T6, EFL/AAG. BFL/(G12+G23), ALT/BFL, (T5+T6)/(G34+G45+G56), ALT+AAG. T3/(G12+G56), ALT/(G34+G56), T4/T5, AAG/T2, and T1/(G23+G56) of the present embodiment.

The distance from the object-side surface **1411** of the first lens element **1410** to the image plane **1480** along the optical axis may be about 4.015 mm, the image height may be about 2.3 mm, and the length of the optical imaging lens **14** may be shortened compared with conventional optical imaging lenses. Thus, the optical imaging lens **14** may be capable of providing excellent imaging quality for smaller sized mobile devices.

FIG. **59**(*a*) shows the longitudinal spherical aberration. From the vertical deviation of each curve shown in FIG. **59**(*a*), the offset of the off-axis light relative to the image point may be within about ±0.045 mm. Furthermore, the three curves having different wavelengths may be closed to each other, and this situation may represent that off-axis light with respect to these wavelengths is focused around an image point, and the aberration can be improved.

FIGS. **59**(*b*) and **59**(*c*) respectively show the astigmatism aberration in the sagittal direction and astigmatism aberration in the tangential direction. Referring to FIG. **59**(*b*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.18 mm. Referring to FIG. **59**(*c*), the focus variation with respect to the three different wavelengths (470 nm, 555 nm, 650 nm) in the whole field may fall within about ±0.16 mm. Additionally, the three curves presenting different wavelengths may be closed to each other, and these closed curves may represent that the dispersion is improved.

Please refer to FIG. **59**(*d*), the variation of the distortion aberration of the optical imaging lens **14** may be within about ±1.6%.

Please refer to FIGS. **62** (A) and **62**(B) for the values of T1, G12, T2, G23, T3, G34, T4, G45, T5, G56, T6, BFL, EFL, ALT, AAG, EFL/(T2+T6), BFL/T4, AAG/T3, ALT/T6, EFL/AAG. BFL/(G12+G23), ALT/BFL, (T5+T6)/(G34+G45+G56), ALT+AAG. T3/(G12+G56), ALT/(G34+G56), T4/T5, AAG/T2, and T1/(G23+G56) of all fourteen embodiments, and it is clear that the optical imaging lens of the present disclosure satisfy the Equations (1)~(14).

Reference is now made to FIG. **63**, which illustrates an example structural view of a first embodiment of mobile device **20** applying an aforesaid optical imaging lens. The mobile device **20** comprises a housing **21** and a photography module **22** positioned in the housing **21**. Examples of the mobile device **20** may be, but are not limited to, a mobile phone, a camera, a tablet computer, a personal digital assistant (PDA), etc.

As shown in FIG. **63**, the photography module **22** has an optical imaging lens with fixed focal length, wherein the photography module **22** may comprise the aforesaid optical imaging lens with six lens elements. For example, photography module **22** comprises the optical imaging lens **1** of the first embodiment, a lens barrel **23** for positioning the optical imaging lens **1**, a module housing unit **24** for positioning the lens barrel **23**, a substrate **182** for positioning the module housing unit **24**, and an image sensor **181** which is positioned at an image side of the optical imaging lens **1**. The image plane **180** is formed on the image sensor **181**.

In some other example embodiments, the structure of the filtering unit **170** may be omitted. In some example embodiments, the housing **21**, the lens barrel **23**, and/or the module housing unit **24** may be integrated into a single component or assembled by multiple components. In some example embodiments, the image sensor **181** used in the present embodiment is directly attached to a substrate **182** in the form of a chip on board (COB) package, and such package is different from traditional chip scale packages (CSP) since COB package does not require a cover glass before the image sensor **181** in the optical imaging lens **1**. Aforesaid exemplary embodiments are not limited to this package type and could be selectively incorporated in other described embodiments.

The six lens elements **110**, **120**, **130**, **140**, **150**, **160** are positioned in the lens barrel **23** in the way of separated by an air gap between any two adjacent lens elements.

The module housing unit **24** comprises a lens backseat **2401** for positioning the lens barrel **23** and an image sensor base **2406** positioned between the lens backseat **2401** and the image sensor **181**. The lens barrel **23** and the lens backseat **2401** are positioned along a same axis I-I', and the lens backseat **2401** is positioned at the inside of the lens barrel **23**. The image sensor base **2406** is exemplarily close to the lens backseat **2401** here. The image sensor base **2406** could be optionally omitted in some other embodiments of the present disclosure.

Because the length of the optical imaging lens **1** may be merely 4.132 mm, the size of the mobile device **20** may be quite small. Therefore, the embodiments described herein meet the market demand for smaller sized product designs.

Reference is now made to FIG. **64**, which shows another structural view of a second embodiment of mobile device **20'** applying the aforesaid optical imaging lens **1**. One difference between the mobile device **20'** and the mobile device **20** may be the lens backseat **2401** comprising a first seat unit **2402**, a second seat unit **2403**, a coil **2404** and a magnetic unit **2405**. The first seat unit **2402** may be close to the outside of the lens barrel **23**, and positioned along an axis I-I', and the second seat unit **2403** may be around the outside of the first seat unit **2402** and positioned along with the axis I-I'. The coil **2404** may be positioned between the outside of the first seat unit **2402** and the inside of the second seat unit **2403**. The magnetic unit **2405** may be positioned between the outside of the coil **2404** and the inside of the second seat unit **2403**.

The lens barrel **23** and the optical imaging lens **1** positioned therein may be driven by the first seat unit **2402** for moving along the axis I-I'. The rest structure of the mobile device **20'** may be similar to the mobile device **20**.

Similarly, because the length of the optical imaging lens **1** may be about 4.132 mm, is shortened, the mobile device **20'** may be designed with a smaller size and meanwhile good optical performance may still be provided. Therefore, the present embodiment may meet the demand of small sized product design and the request of the market.

According to above illustration, it is clear that the mobile device and the optical imaging lens thereof in example embodiments, through controlling the detail structure of the lens elements and an inequality, the length of the optical imaging lens may be effectively shortened and meanwhile good optical characteristics are still provided.

While various embodiments in accordance with the disclosed principles been described above, it should be understood that they are presented by way of example only, and are not limiting. Thus, the breadth and scope of exemplary embodiment(s) should not be limited by any of the above-described embodiments, but should be defined only in accordance with the claims and their equivalents issuing from this disclosure. Furthermore, the above advantages and features are provided in described embodiments, but shall not limit the application of such issued claims to processes and structures accomplishing any or all of the above advantages.

Additionally, the section headings herein are provided for consistency with the suggestions under 37 C.F.R. 1.77 or otherwise to provide organizational cues. These headings shall not limit or characterize the invention(s) set out in any claims that may issue from this disclosure. Specifically, a description of a technology in the "Background" is not to be construed as an admission that technology is prior art to any invention(s) in this disclosure. Furthermore, any reference in this disclosure to "invention" in the singular should not be used to argue that there is only a single point of novelty in this disclosure. Multiple inventions may be set forth according to the limitations of the multiple claims issuing from this disclosure, and such claims accordingly define the invention(s), and their equivalents, that are protected thereby. In all instances, the scope of such claims shall be considered on their own merits in light of this disclosure, but should not be constrained by the headings herein.

What is claimed is:

1. An optical imaging lens, sequentially from an object side to an image side along an optical axis, comprising an aperture stop, first, second, third, fourth, fifth and sixth lens elements, each of said first, second, third, fourth, fifth and sixth lens elements having refracting power, an object-side surface facing toward the object side and an image-side surface facing toward the image side and a central thickness defined along the optical axis, wherein:

said image-side surface of said first lens element comprises a convex portion in a vicinity of the optical axis;

said object-side surface of said second lens element comprises a concave portion in a vicinity of a periphery of the second lens element;

said object-side surface of said third lens element comprises a convex portion in a vicinity of a periphery of the third lens element;

said fourth lens element is constructed by plastic material;

said image-side surface of said fifth lens element comprises a concave portion in a vicinity of the optical axis;

said image-side surface of said sixth lens element comprises a concave portion in a vicinity of the optical axis;

an effective focal length of the optical imaging lens is represented by EFL, a central thickness of the second lens element is represented by T2, a central thickness of the sixth lens element is represented by T6, EFL, T2 and T6 satisfy the equation: $EFL/(T2+T6)\leq 5.9$; and

a sum of all five air gaps from the first lens element to the sixth lens element along the optical axis is represented by AAG, AAG and EFL satisfy the equation: $EFL/AAG\geq 4.0$;

the optical imaging lens comprises no other lenses having refracting power beyond the six lens elements.

2. The optical imaging lens according to claim **1**, wherein a back focal length of the optical imaging lens, which is defined as the distance from the image-side surface of the sixth lens element to an image plane along the optical axis is represented by BFL, a central thickness of the fourth lens element is represented by T4, BFL and T4 satisfy the equation: $BFL/T4\geq 1.8$.

3. The optical imaging lens according to claim **2**, wherein a central thickness of the fifth lens element is represented by T5, an air gap between the third lens element and the fourth lens element along the optical axis is represented by G34, an air gap between the fourth lens element and the fifth lens element along the optical axis is represented by G45, an air gap between the fifth lens element and the sixth lens element along the optical axis is represented by G56, T5, T6, G34, G45, and G56 satisfy the equation: $(T5+T6)/(G34+G45+G56)\geq 1.5$.

4. The optical imaging lens according to claim **1**, wherein the central thickness of the third lens element is represented by T3, AAG and T3 satisfy the equation: $AAG/T3\leq 2.4$.

5. The optical imaging lens according to claim **4**, wherein a sum of the central thicknesses of all six lens elements along the optical axis is represented by ALT, ALT and AAG satisfy the equation: $ALT+AAG\leq 6$ mm.

6. The optical imaging lens according to claim **1**, wherein a sum of the central thicknesses of all six lens elements along the optical axis is represented by ALT, ALT and T6 satisfy the equation: $ALT/T6\geq 5.5$.

7. The optical imaging lens according to claim **6**, wherein a central thickness of the third lens element is represented by T3, an air gap between the first lens element and the second lens element along the optical axis is represented by G12 an air gap between the fifth lens element and the sixth lens element along the optical axis is represented by G56, T3, G12 and G56 satisfy the equation: $T3/(G12+G56)\geq 1.0$.

8. The optical imaging lens according to claim **1**, wherein a sum of the central thicknesses of all six lens elements along the optical axis is represented by ALT, an air gap between the third lens element and the fourth lens element along the optical axis is represented by G34, an air gap between the fifth lens element and the sixth lens element along the optical axis is represented by G56, ALT, G34 and G56 satisfy the equation: $ALT/(G34+G56)\geq 4.6$.

9. The optical imaging lens according to claim **1**, wherein a central thickness of the fourth lens element is represented by T4, a central thickness of the fifth lens element is represented by T5, T4 and T5 satisfy the equation: $T4/T5\leq 1.5$.

10. The optical imaging lens according to claim **1**, wherein a back focal length of the optical imaging lens, which is defined as the distance from the image-side surface of the sixth lens element to the image plane along the optical axis is represented by BFL, an air gap between the first lens element and the second lens element along the optical axis is represented by G12, an air gap between the second lens element and the third lens element along the optical axis is represented by G23, BFL, G12 and G23 satisfy the equation: $BFL/(G12+G23)\geq 3.0$.

11. The optical imaging lens according to claim **10**, wherein a sum of all five air gaps from the first lens element to the sixth lens element along the optical axis is represented by AAG, a central thickness of the second lens element is represented by T2, AAG and T2 satisfy the equation: $AAG/T2\leq 3.8$.

12. The optical imaging lens according to claim **1**, wherein a sum of the central thicknesses of all six lens elements along the optical axis is represented by ALT, a back focal length of the optical imaging lens, which is defined as the distance from the image-side surface of the sixth lens element to the image plane along the optical axis is represented by BFL, ALT and BFL satisfy the equation: $ALT/BFL\leq 2.5$.

13. The optical imaging lens according to claim **12**, wherein a central thickness of the first lens element is represented by T1, an air gap between the second lens element and the third lens element along the optical axis is represented by G23, an air gap between the fifth lens element and the sixth lens element along the optical axis is represented by G56, T1, G23 and G56 satisfy the equation: $T1/(G23+G56)\geq 1.25$.

14. A mobile device, comprising:

a housing; and

a photography module positioned in the housing and comprising:

an optical imaging lens according to claim **1**;

a lens barrel for positioning the optical imaging lens;

a module housing unit for positioning the lens barrel; and

an image sensor positioned at the image side of the optical imaging lens.

* * * * *