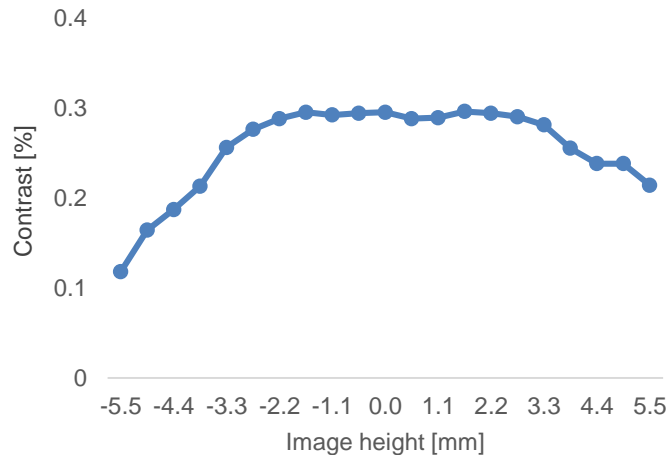


MV Lens Comparison Test Report

By Trioptics Japan Co., Ltd.



Note:
This report does not guarantee the performance of all tested lenses. Distribution of this report is prohibited to third parties without the prior consent of RICOH.

RICOH Industrial Solutions Inc.
Electronics Business Division
Sales and Marketing Dept.
Solution Sales Sec.



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It is possible to make a lens comparison by using the lens specifications in our catalogue and simulated data, but I wonder if lens comparisons really represents actual lens performance?

Conversely, we want to reduce evaluation time.

Responding to such customers' requests, **we have conducted lens performance evaluation of actual lenses** with the cooperation of Trioptics Japan Co., Ltd.

We hope this report may be of help to you with your lens selection.





Criteria

- ① MTF
- ② One-Side Blurry Phenomenon
- ③ Depth of Field

Conditions

Sensor:	2/3" Diagonal 11mm (± 5.5 mm)
F-Stop:	F:2.0
Working Distance :	250mm (From flange surface to reticle)
Measurement Direction:	Horizontal, vertical, diagonal 40° (from horizontal) Maximum 3 axes
Nyquist frequency :	147lp/mm

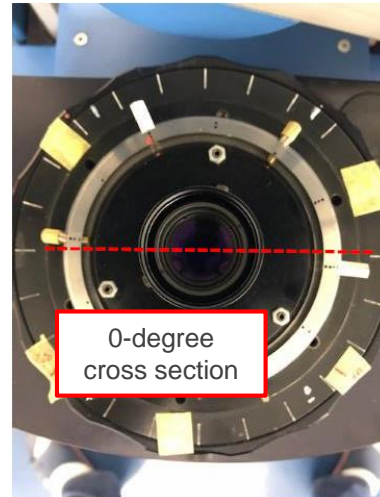
Models

Lens No	Model	Format	Max. Aperture	Direction of Measurement
1	FL-CC2518-5MX	2/3"	1.8	0° ,40° ,90°
2	Maker A-5MP	2/3"	1.6	0° ,40° ,90°
3	Maker B-5MP	1/1.2"	1.8	0° ,40° ,90°
4	Maker C-5MP	2/3"	1.6	40°
5	Maker C-10MP	2/3"	1.8	40°
6	Maker D-5MP	2/3"	1.4	40°
7	FL-CC2514A-2M	2/3"	1.4	40°
8	Maker C-MP	2/3"	1.4	40°
9	Maker D-MP1	1/1.8"	1.8	40°
10	Maker D-MP2	2/3"	2.1	40°

Test Machine



Mounted Lens

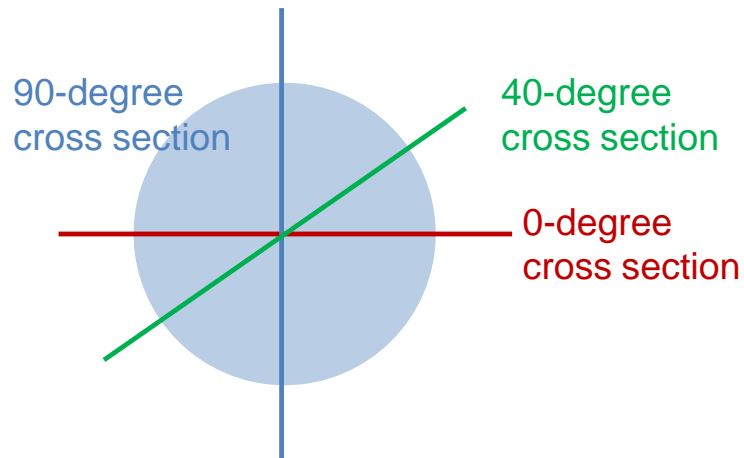


Marking Position

Lens measured with the indicator line frontwards



Measurement Directions



Set the lens with the indicator line at 6 o'clock position and define the position of the 0-degree cross section direction as shown. Based on the 0-degree direction, measure performance values at 40 and 90-degree cross sections.

Overall Results

Section 1) 5MP Class Lenses with 6 grade evaluation

Section 2) 2MP Class Lenses with 4 grade evaluation.

Results listed separately by class. **Higher grade indicates better performance.**

Model	Resolution	MTF at center	MTF at periphery	MTF effective resolution	Depth of field	Total Score
1) 5MP Class						
FL-CC2518-5MX	5MP	4	5	6	6	21
Maker A-5MP	5MP	3	3	3	1	10
Maker B-5MP	5MP	5	2	4	5	16
Maker C-5MP	5MP	6	4	5	4	19
Maker C-10MP	10MP	1	6	2	2	11
Maker D-5MP	5MP	3	1	1	3	10
2) MP Class						
FL-CC2514A-2M	2MP	4	3	3	4	14
Maker A-MP	MP	3	4	4	2	13
Maker D-MP1	MP	2	2	2	3	9
Maker D-MP2	MP	1	1	1	1	4

Definition

MTF at center: Comparison of the MTF at the center

MTF at periphery: Comparison of the MTF at the image height of $\pm 5.5\text{mm}$

MTF effective resolution: Comparison with 20% or more of MTF to Nyquist frequency 147lp/mm

Depth of field: Dept of field with 10% or more of MTF to Nyquist frequency 147lp/mm



MTF Comparison





Do you have problems like this?



Optical performance was too low, so that:

- I had to increase the number of cameras or use a higher resolution lens.
- It was time consuming or difficult to align the target centrally in the image.



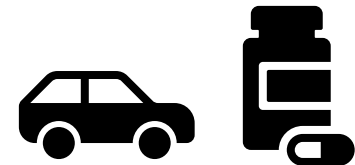
RICOH lens covers a wider area from the center to periphery and fits to a narrow place in a compact machine.

High definition right up to the peripheries means...

- The high-resolution area is wide and so all the field of view can be used efficiently for image analysis.
- Finds defects on the peripheries to improve manufacturing yield.

Ideal Applications

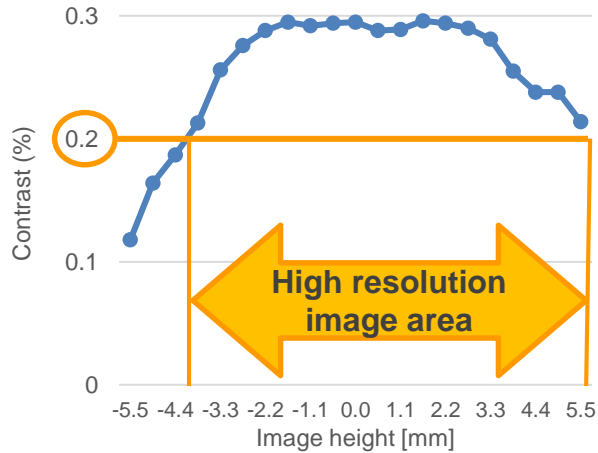
Inspection of products not aligned at the center of conveyers such as tablets, fruits and flour.
Inspection of automotive parts and larger devices.



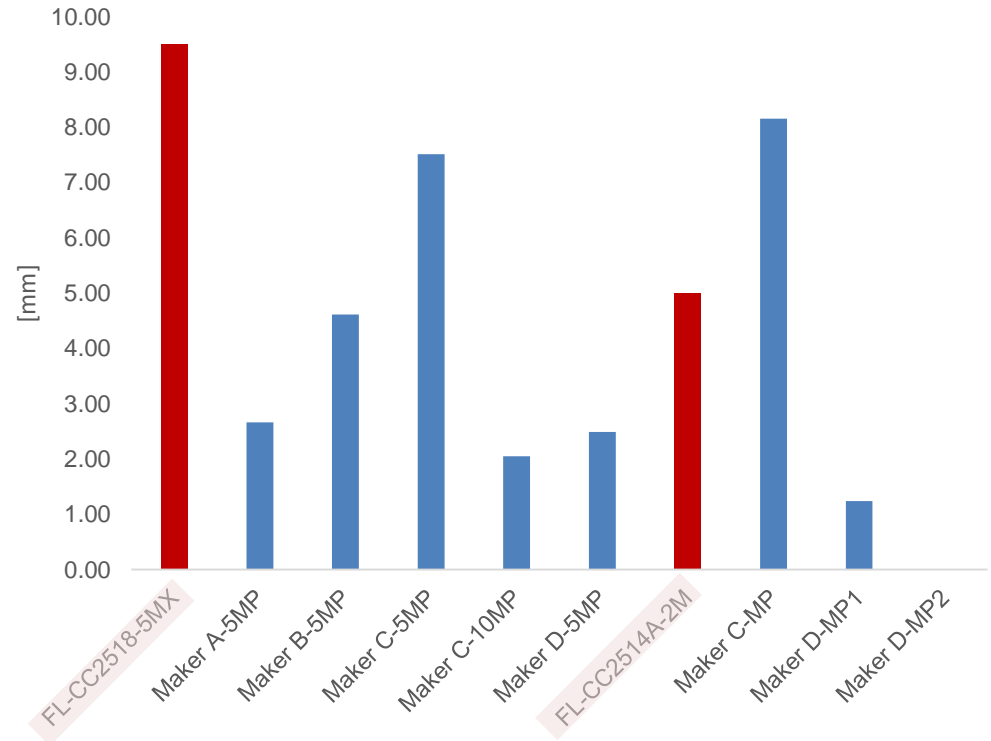


MTF Measurement Results

MTF Graph



High resolution image area



High resolution image area: Area with 20% MTF or more within the image height ± 5.5 mm

- FL-CC2518-5MX produces the highest resolution through to the peripheries.
- FL-CC2514A-2M produces the wider high-resolution image area than other manufacturers.



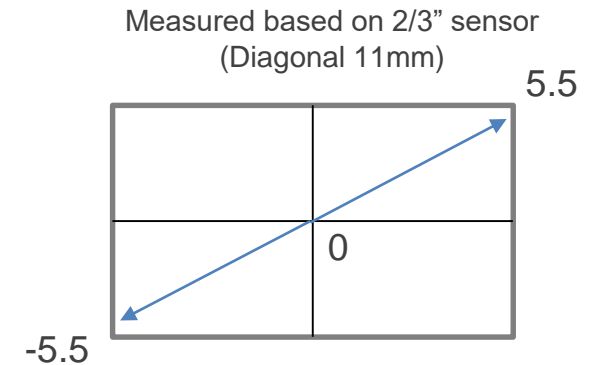
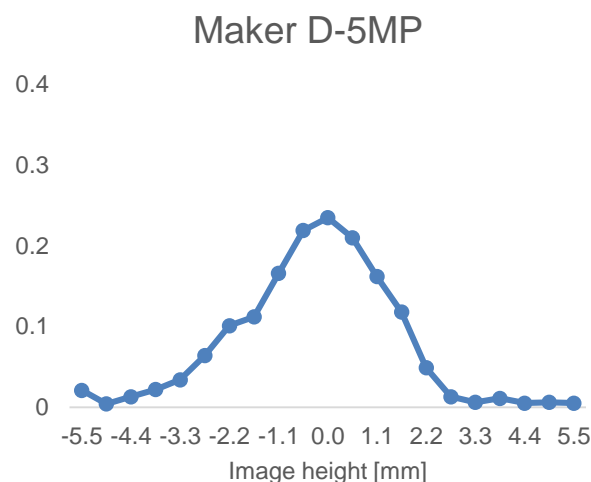
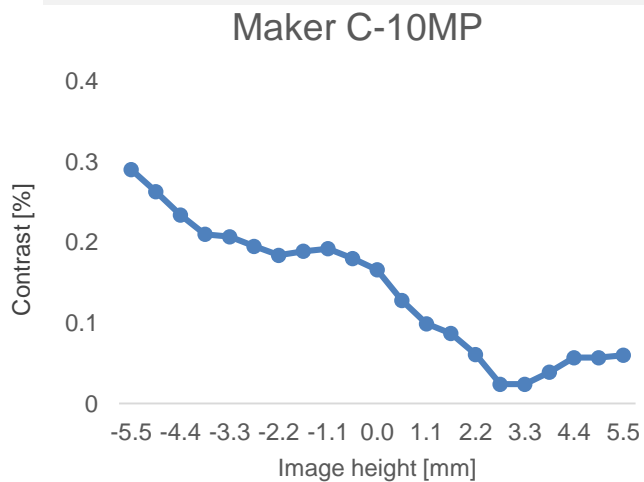
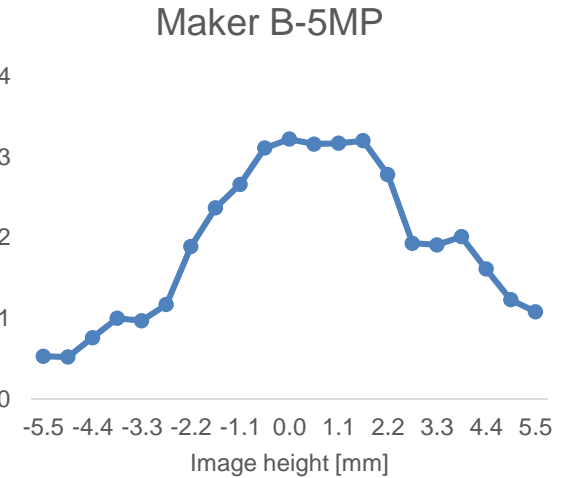
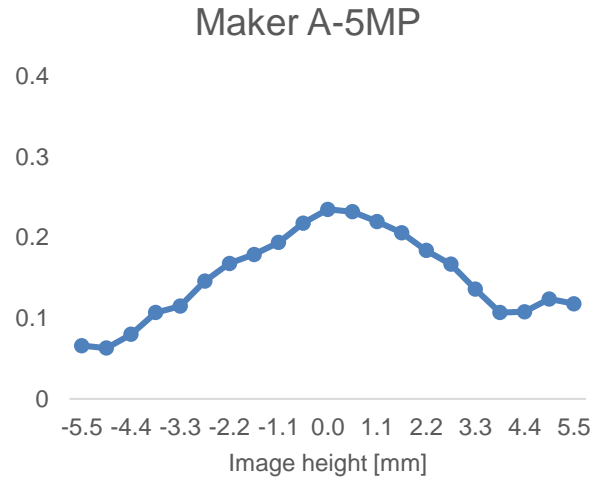
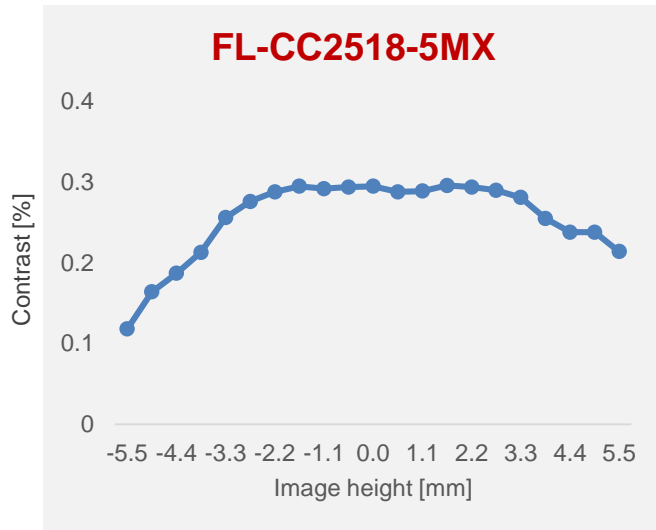
It has been proved that the actual lenses produced higher resolution through to the peripheries without degradation in the corners of the image.

*Along with Japan Industrial Imaging Association (JIIA) Technical Report, this report also sets the "Resolution" threshold as MTF20%..



MTF Measurement Results (5MP~)

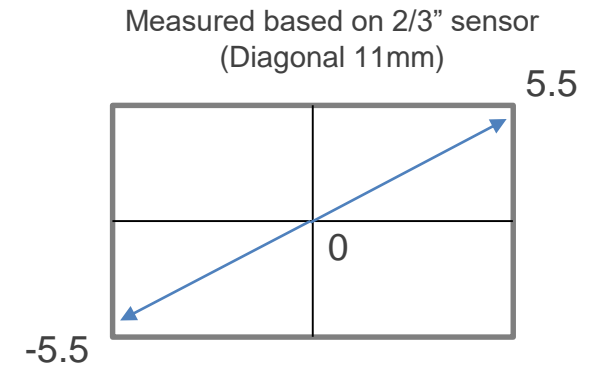
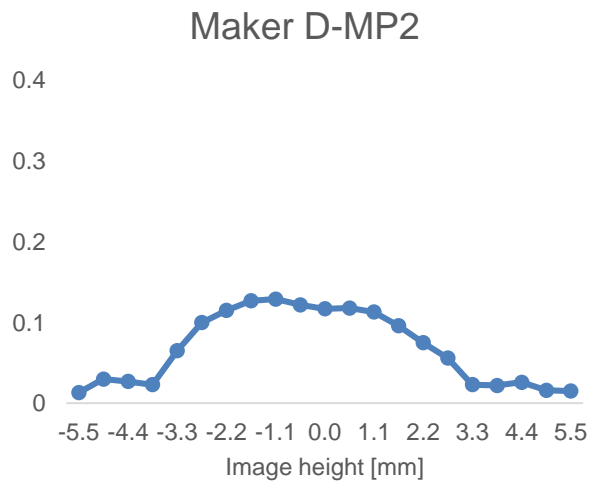
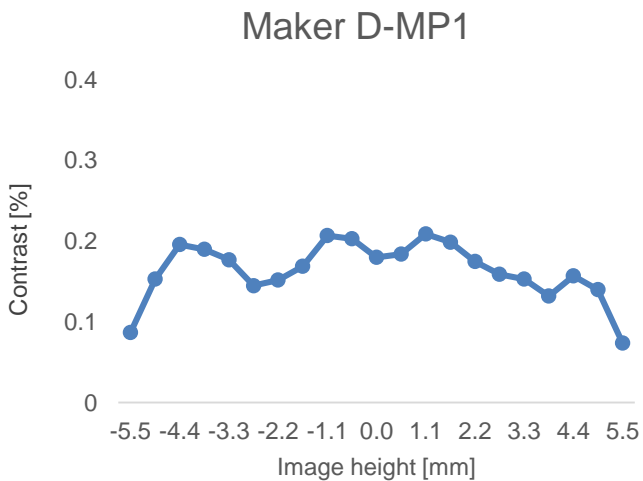
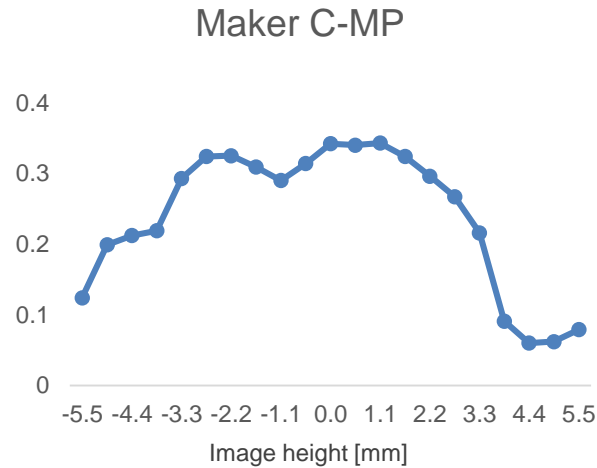
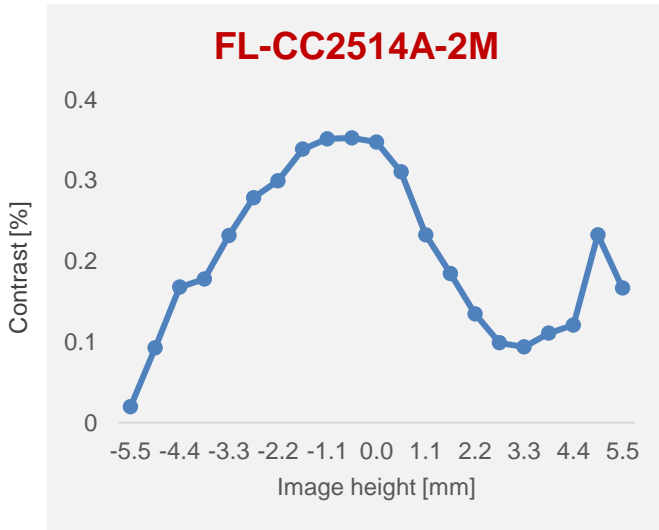
Graphs of the lowest produced MTF from tangential, sagittal or diagonal (40-degree) directions





MTF Measurement Results (MP)

Graphs of the lowest produced MTF from tangential, sagittal or diagonal (40-degree) directions





Focusing Performance Comparison

- One-side blurry Phenomenon
- Depth of field





Focusing Performance Comparison

- One-side blurry Phenomenon
- Depth of field



What is One-side blurry Phenomenon?

In an image, you may have seen differences in resolution top and bottom or left and right of the image. This is the one-side blurry phenomenon.

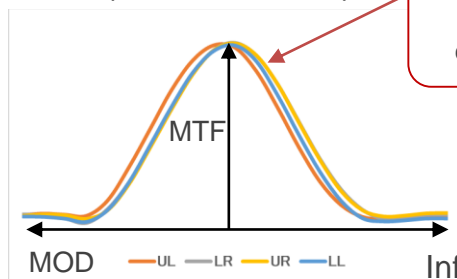
When focused on the center, you may find either the left side or right of the image is out of focus. It may be likely resulting from the one-sided blurry phenomenon.

The one-side blurry phenomenon is due to uncentered and/or tilted lens elements. Comprehensive technology in design, assembly and alignment is one of the key factors required for eradication of the one-side blurry phenomenon.

Lens without one-side blurry phenomenon

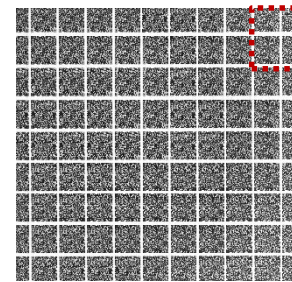


M-D Graph
(MTF-Defocus)

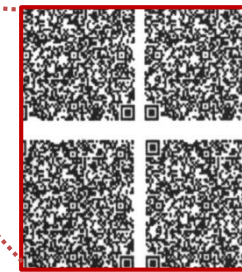


MTF peaks are all centered

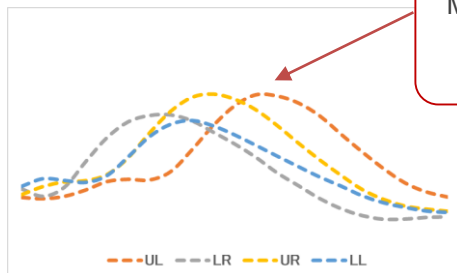
Actual image (WD=900mm)



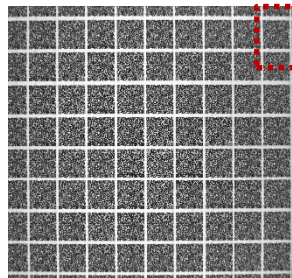
Periphery



Lens with one-side blurry phenomenon



MTF peaks are scattered





Do you have any problems like this?



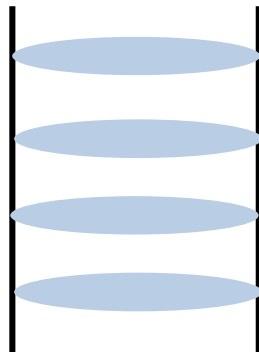
- Set focus on one side of an image, but the other area is out of focus.
 - Set focus on the center of the image, but the other sides are blur.
- This may be caused by **one-side blurry phenomenon**.



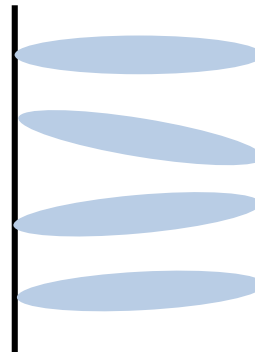
The one-side blurry phenomenon is due to poor lens manufacturing and assembly.

RICOH with its high-level production engineering, thoroughly aligns and controls from design to production. It only supplies high-quality products to customers.

Assembled lenses without tilting



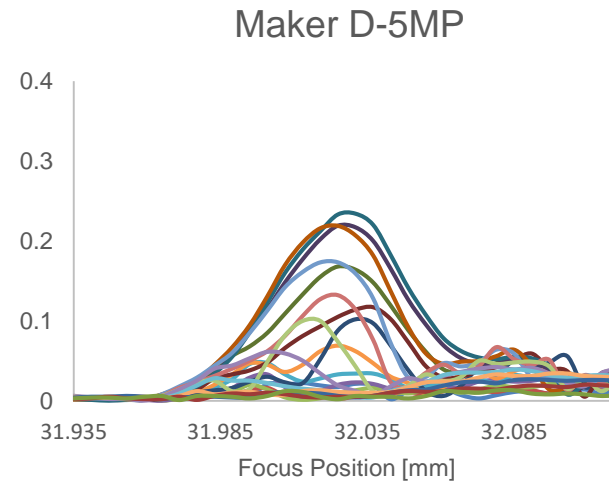
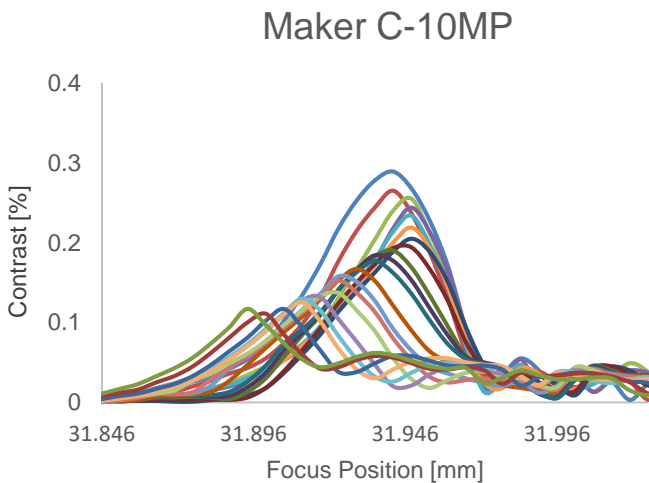
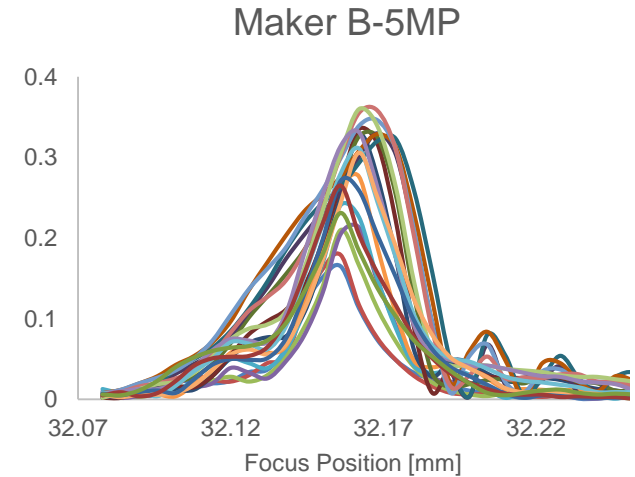
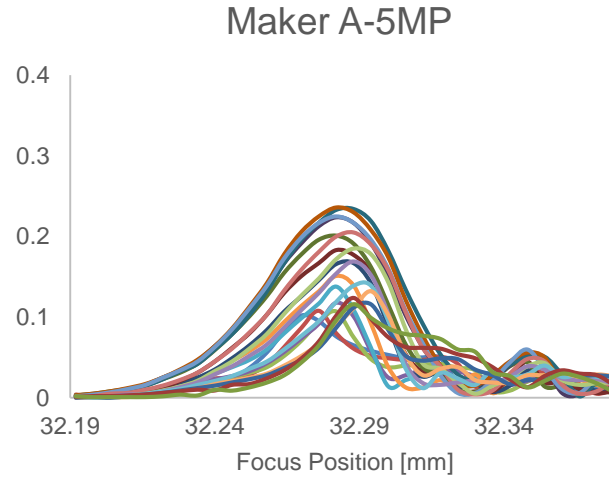
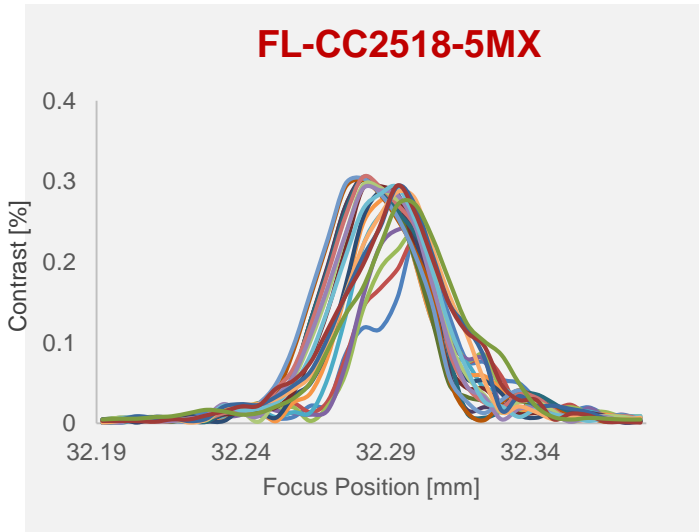
Assembled lenses with tilting





M-D Measurement Results (5MP~)

Graphs of **the lowest** produced MTF from tangential, sagittal or diagonal (40-degree) directions
The graphs represent **resolution** corresponding to each image height from 0mm to ± 5.5 mm.



Cross reference: Color and image height

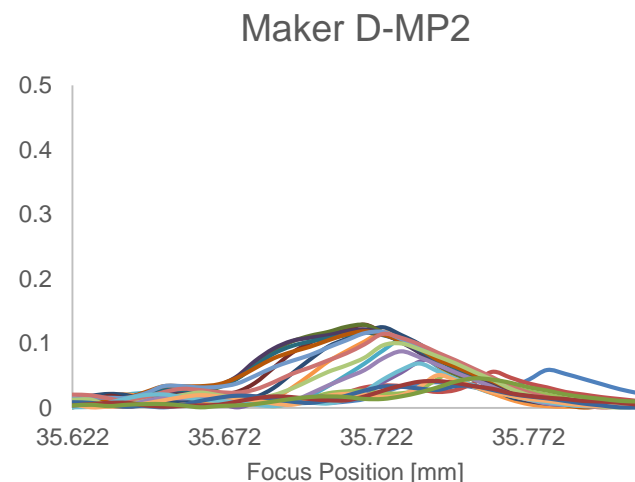
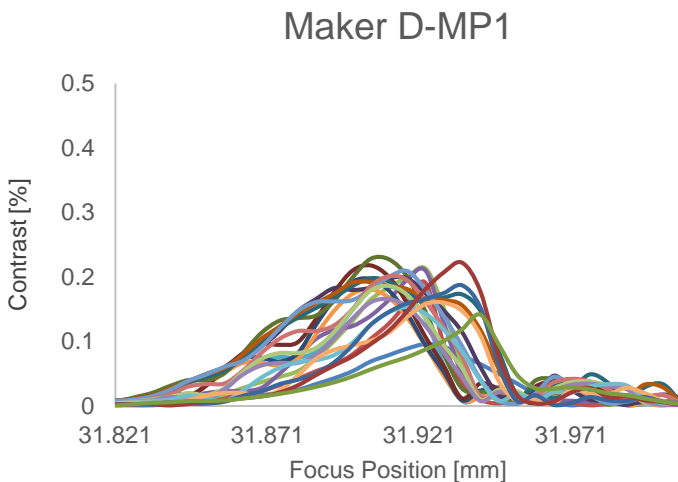
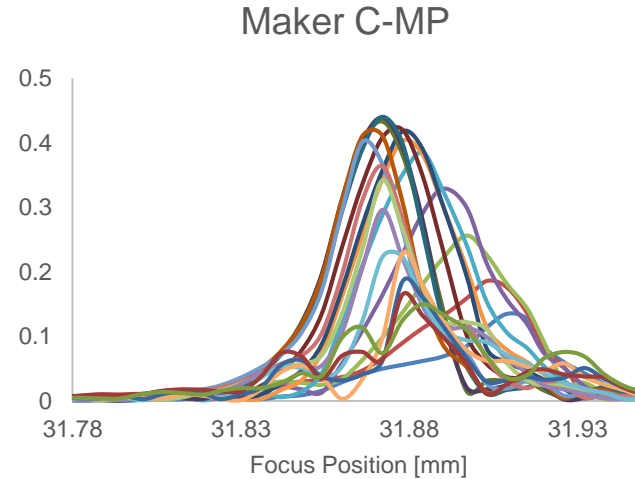
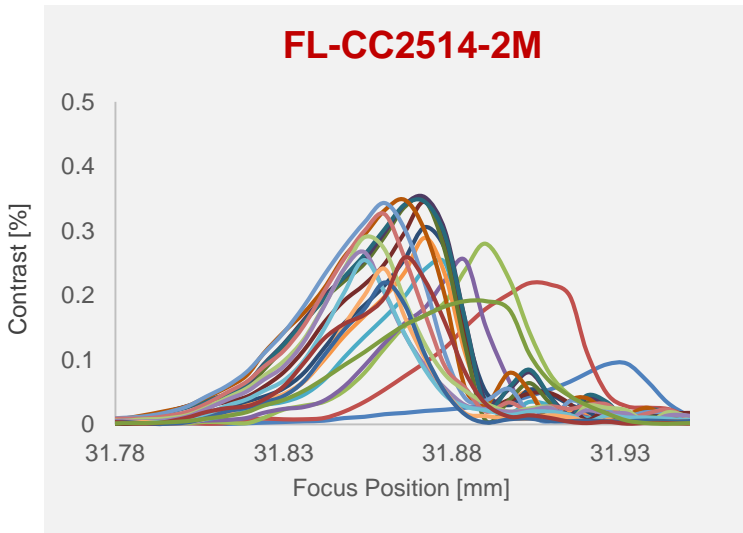
- -5.5 — -4.95 — -4.4
- -3.85 — -3.3 — -2.75
- -2.2 — -1.65 — -1.1
- -0.55 — 0 — 0.55
- 1.1 — 1.65 — 2.2
- 2.75 — 3.3 — 3.85
- 4.4 — 4.95 — 5.5

Working Distance : 250mm
F-Stop : F2.0
Nyquist frequency : 147lp/mm



M-D Measurement Results (MP)

Graphs of **the lowest** produced MTF from tangential, sagittal or diagonal (40-degree) directions
The graphs represent **resolution** corresponding to each image height from 0mm to ± 5.5 mm.



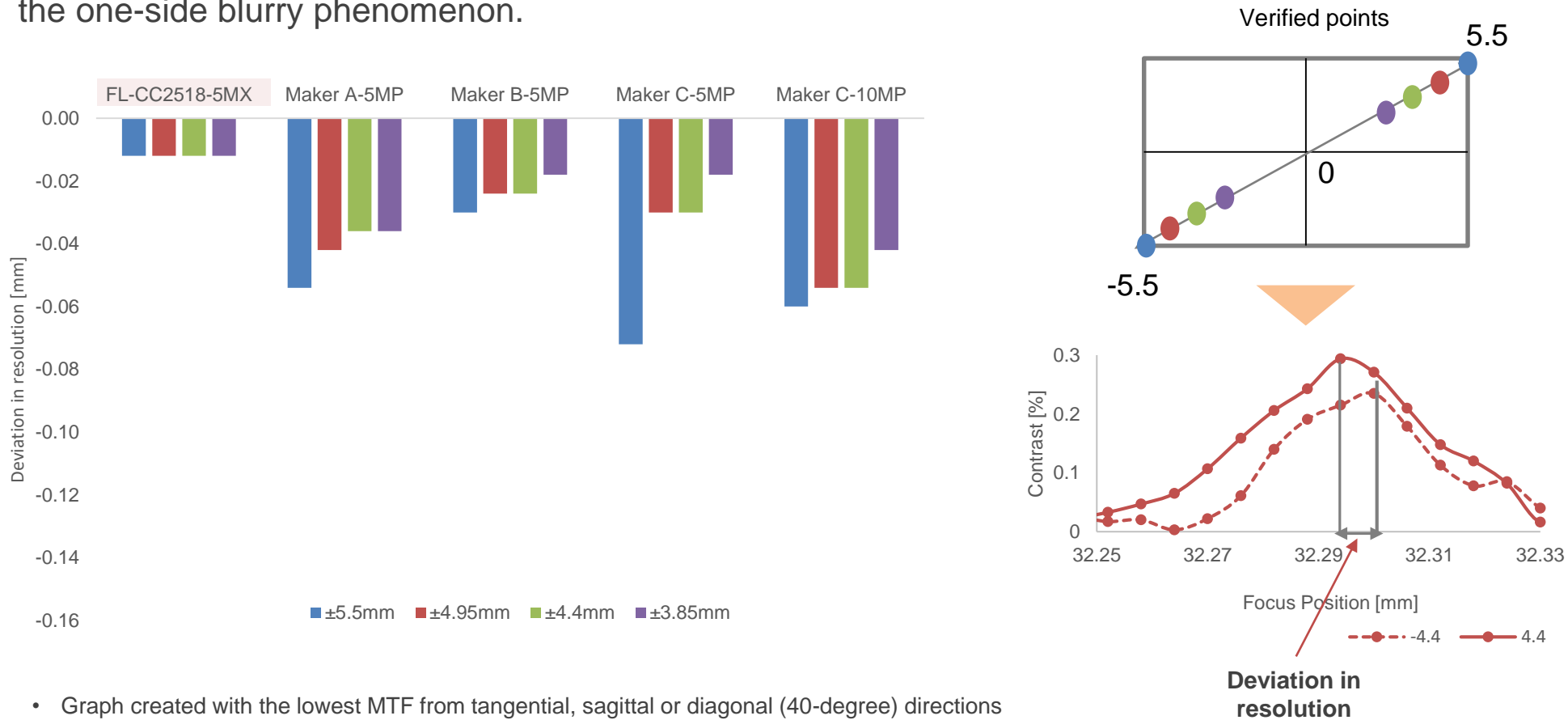
Cross reference: Color and image height

- | | | |
|---------|---------|---------|
| — -5.5 | — -4.95 | — -4.4 |
| — -3.85 | — -3.3 | — -2.75 |
| — -2.2 | — -1.65 | — -1.1 |
| — -0.55 | — 0 | — 0.55 |
| — 1.1 | — 1.65 | — 2.2 |
| — 2.75 | — 3.3 | — 3.85 |
| — 4.4 | — 4.95 | — 5.5 |

Working Distance : 250mm
F-Stop : F2.0
Nyquist frequency : 147lp/mm

One-Side Blurry Verification (Selected 5MP) **RICOH** imagine. change.

RICOH lenses provide **the least amount of deviation even at the image peripheries** and reproduce an even image across the sensor without producing the one-side blurry phenomenon.



- Graph created with the lowest MTF from tangential, sagittal or diagonal (40-degree) directions
- Maker D-5MP is excluded since the peaks distributed unequally.
- Deviation in resolution means the difference between focusing points when left and right MTFs reach their respective peaks. The greater the deviation, the worse the one-side blurry phenomenon produced.



Focusing Performance Comparison

- One-side blurry
- Depth of field

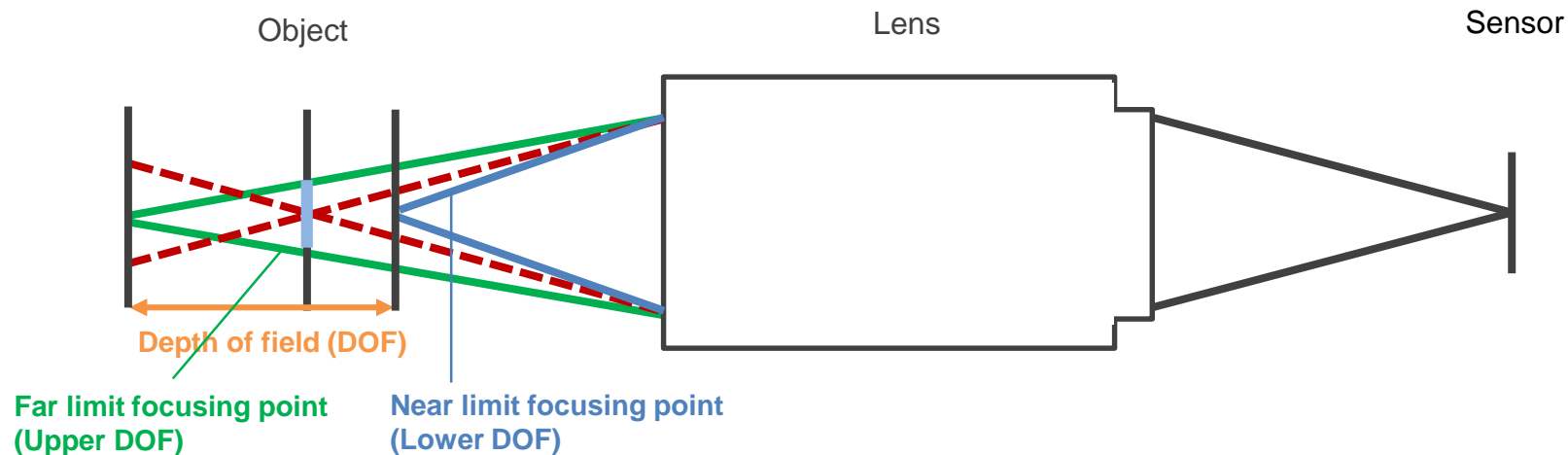


What is depth of field?

The distance between the two planes which define the limits of acceptable image sharpness when a lens is focused on an object.

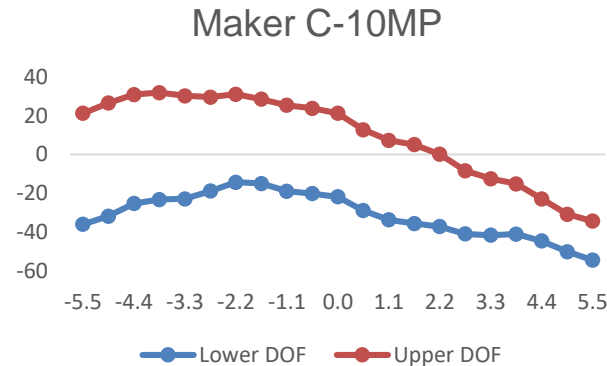
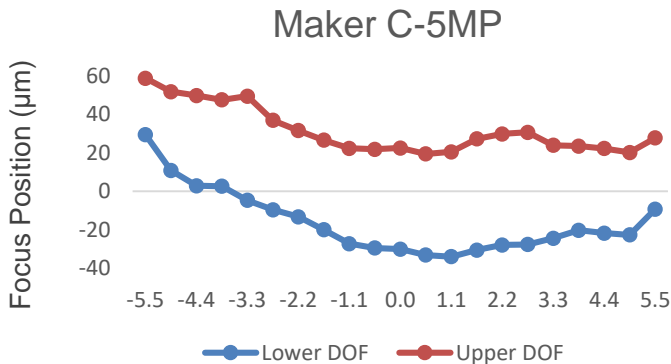
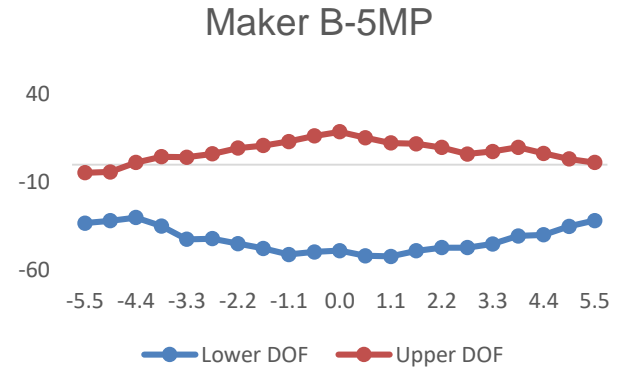
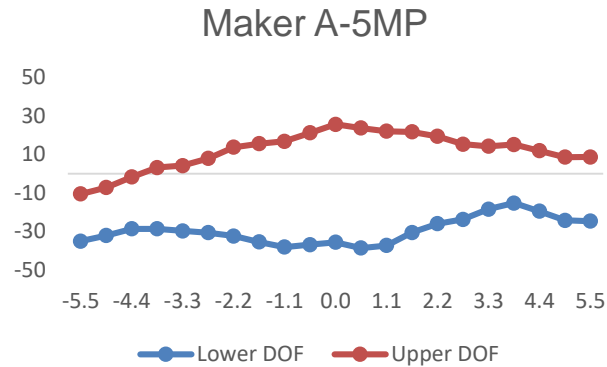
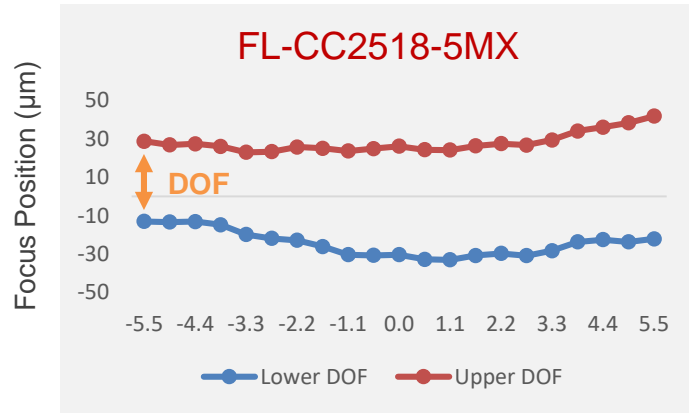
A lens with greater depth of field can focus in front of and behind the object at the focal point and maintain focus on the extremes of the object.

In this measurement, the range for 10% MTF or higher is defined and measured as the depth of field.



Depth of Field Range (5M~)

The graphs show Lower and Upper DOF at each image height from 0mm to ± 5.5 mm with 10% MTF or higher.



Working Distance : 250mm

F-stop : F2.0

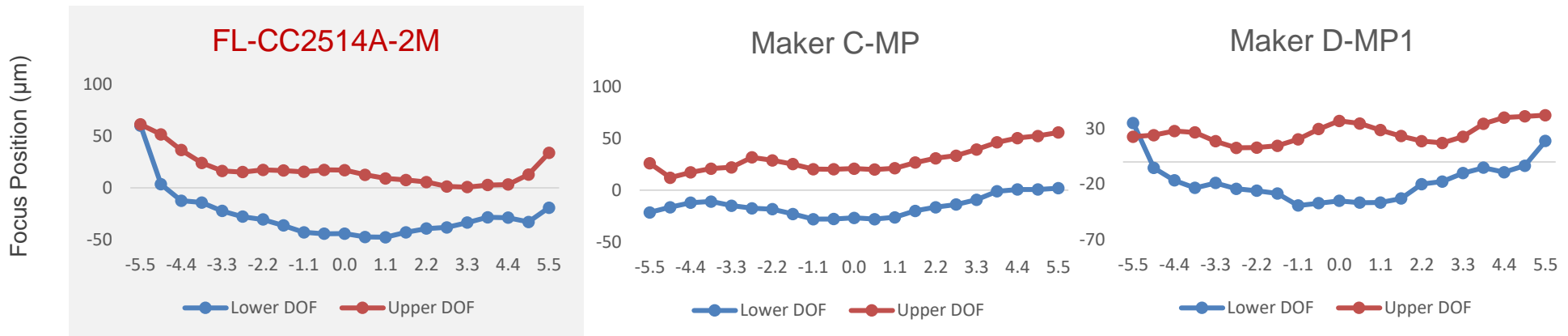
Nyquist frequency : 147lp/mm

Lower DOF : Near limit focusing point Upper DOF : Far limit focusing point

Depth of field of Maker D 5MP lens and Maker D MP2 lens is negative and omitted from this comparison.

Depth of Field Range (MP)

The graphs show Lower and Upper DOF at each image height from 0mm to ± 5.5 mm with 10% MTF or higher.



Working Distance : 250mm

F-stop : F2.0

Nyquist frequency : 147lp/mm

Lower DOF : Near limit focusing point Upper DOF : Far limit focusing point

Depth of field of Maker D 5MP lens and Maker D MP2 lens is negative and omitted from this comparison.

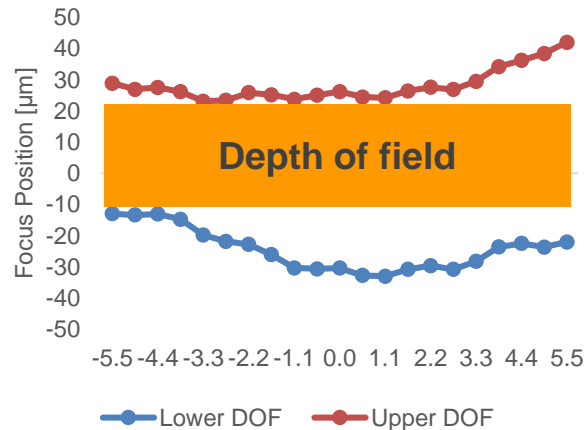
Depth of Field Comparison

FL-CC2518-5MX performs the widest range of depth of field and best focus on objects with surface irregularities or at different distances.

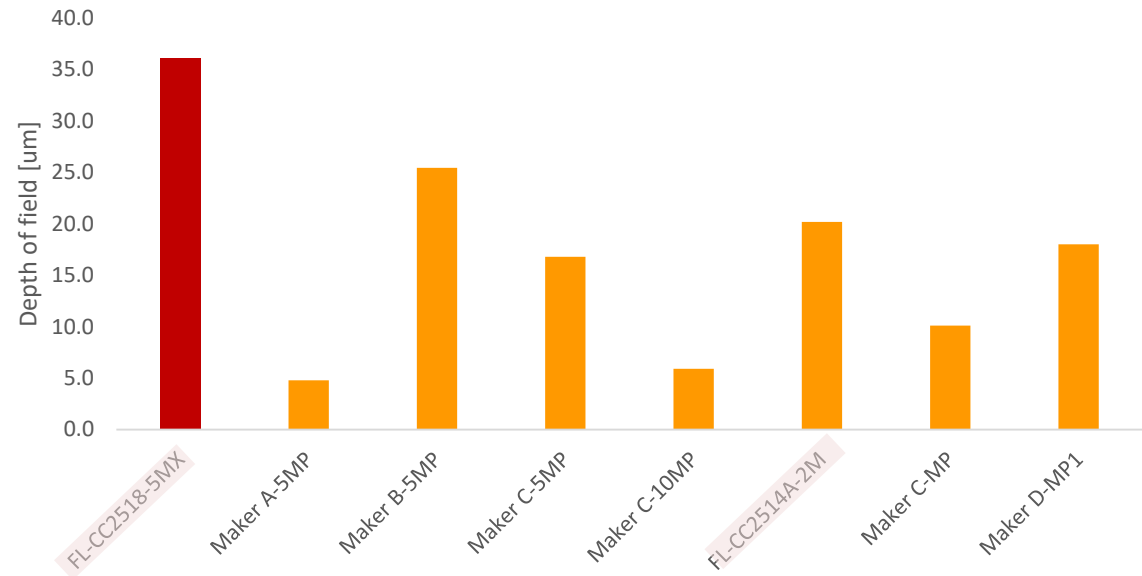
Ideal Applications

Inspection of objects with surface irregularities or placed at difference distances.

Focus Position Graph



Depth of Focus Range



Depth of field = (Min of Upper DOF) – (Max of Lower DOF)

Depth of field of Maker D 5MP lens and Maker D MP2 lens is negative and omitted from this comparison.

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