NEW

UIS2/UIS OBJECTIVE LENSES

UNIVERSAL INFINITY SYSTEM

UIS2/UIS optical characteristics of objective lenses for industrial and metallurgical applications.





MPLFLN (-BD) Plan SemiApochromat series

These Plan SemiApochromat objective lenses completely eliminate chromatic aberration at high level, which is perfect for a wide range of microscopic methods including brightfield (darkfield), fluorescence, Nomarski DIC and simple polarized observation. All 50x or higher objective lenses have 1mm working distance to fulfill safe approach to the specimen. Since exit pupil positions from 5x through 150x are standardized, no switching of the DIC prism lever position is necessary when the objective lens power changes.



MPLFLN-BDP Plan SemiApochromat series

The Plan SemiApochromat POL design ensures through compensation for coma aberration. Distortion is also minimized, which makes these objective lenses the best choice for Nomarski DIC microscopy.





LMPLFL (-BD) Plan SemiApochromat Series

These Plan SemiApochromat objectives feature a long working distance which makes it easy to change samples without touching the coarse focus.





MPLN (-BD) Plan Achromat series

Plan Achromat objective lenses with excellent flatness up to F.N. 22. Use the BD series in brightfield and darkfield observation.



LCPLFLN-LCD series

The perfect objective lenses for sample observation through an LCD panel or other glass plate. Aberration correction matched to the glass thickness is possible by using a correction ring.



LMPlan-IR, MPlan-IR series

Plan SemiApochromat objective lenses which compensate for aberrations from visible to near infrared light.



SLMPlan series

Long working distance allows observation of fine line widths in high contrast observation with no chromatic shift.



MPlanAPO (-BD) Plan Apochromat series

Plan Apochromat objective lenses with optimal chromatic aberration correction.

Lens Optical character	Magnification	N.A.	W.D. (mm)	Cover glass thickness (mm)	Resolution *2 (µm)
MPLFLN	1.25x*3*5*6	0.04	3.5	—	8.39
	2.5x*3*6	0.08	10.7	—	4.19
	5x	0.15	20.0	—	2.24
	10x	0.30	11.0	—	1.12
	20x	0.45	3.1	0	0.75
	50x	0.80	1.0	0	0.42
	100x	0.90	1.0	0	0.37
MPLFLN-BD*4	5x	0.15	12.0	—	2.24
	10x	0.30	6.5	—	1.12
	20x	0.45	3.0	0	0.75
	50x	0.80	1.0	0	0.42
	100x	0.90	1.0	0	0.37
	150x	0.90	1.0	0	0.37
MPLFLN-BDP*4	5x	0.15	12.0	—	2.24
	10x	0.25	6.5	—	1.34
	20x	0.40	3.0	0	0.84
	50x	0.75	1.0	0	0.45
	100x	0.90	1.0	0	0.37
LMPLFLN	5x	0.13	22.5	—	2.58
	10x	0.25	21.0	—	1.34
	20x	0.40	12.0	0	0.84
	50x	0.50	10.6	0	0.67
	100x	0.80	3.4	0	0.42
LMPLFLN-BD*4	5x	0.13	15.0	—	2.58
	10x	0.25	10.0	—	1.34
	20x	0.40	12.0	0	0.84
	50x	0.50	10.6	0	0.67
	100x	0.80	3.3	0	0.42
MPLN*3	5x	0.10	20.0	—	3.36
	10x	0.25	10.6	—	1.34
	20x	0.40	1.3	0	0.84
	50x	0.75	0.38	0	0.45
	100x	0.90	0.21	0	0.37
MPLN-BD*1*3*4	5x	0.10	12.0	—	3.36
	10x	0.25	6.5	—	1.34
	20x	0.40	1.3	0	0.84
	50x	0.75	0.38	0	0.45
	100x	0.90	0.21	0	0.37
LCPLFLN-LCD*6	20x	0.45	8.3- 7.4	0 - 1.2	0.75
	50x	0.70	3.0 - 2.2	0 - 1.2	0.48
	100x	0.85	1.2 - 0.9	0 - 0.7	0.39

Lens Optical character	Magnification	N.A.	W.D. (mm)	Cover glass thickness (mm)	Resolution *2 (µm)
MPlanApo	20x	0.60	0.9	0	0.56
	50x	0.95	0.3	0	0.35
	100x	0.95	0.35	0	0.35
	100xOil	1.40	0.1	0	0.24
MPlanApo-BD	100x	0.90	0.31	0	0.37
SLMPlan	20x	0.35	21.0	0	0.96
	50x	0.45	15.0	0	0.75
LMPlan-IR	5x	0.10	20.0	—	—
	10x	0.25	18.5	—	—
	20x	0.40	8.1	—	
	50x	0.55	6.0	—	—
	100x	0.80	3.4	—	—
MPlan-IR*3	100x	0.95	0.3	—	—

* "BD" = "Brightfield/darkfield" objective lenses

*1 Slight vignetting may occur in the periphery of the field when MPLN-BD series objective lenses are used with high-intensity light sources such as mercury and xenon for darkfield observation.
*2 Resolutions calculated with aperture iris diaphragm wide open.
*3 Limited up to F.N. 22. No compliance with F.N. 26.5.
*4 BD objective lenses cannot be combined with BX41M-ESD.
*5 Analyzer and polarizer are recommended to the usage with MPLFLN1.25x or 2.5x.
*6 MPLFLN1.25x, 2.5x and LCPLFLN-LCD series are to be available in the beginning of 2007.

UIS2/UIS EYEPIECES

UNIVERSAL INFINITY SYSTEM



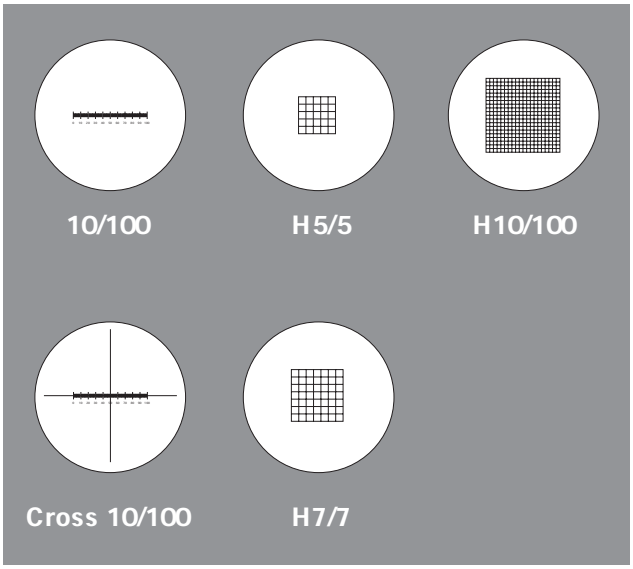
Product	F.N.	Diopter (1/m)	Micrometer (mm)	Remarks
WHN10x	22	—	24	—
WHN10x-H	22	-8 - +2	24	with helicoid
CROSS WHN10x	22	-8 - +2	—	with cross, helicoid
WH15x	14	—	24	—
SWH10x-H	26.5	-8 - +2	—	with helicoid
MICRO SWH10x	26.5	-8 - +2	—	with micrometer, helicoid
CROSS-SWH10x	26.5	-8 - +2	—	with cross, helicoid

UIS2 World-leading optics

OC-M

MICROMETER RETICLES (ø20.4mm)

When the OC-M is inserted into the WHN10x eyepiece filed iris diaphragm, the length of the specimen within the field of view can be measured.
Various types are available to choose from depending on the specimen.



OC-M Specifications

10/100	10mm in 100 divisions
Cross 10/100	10mm in 100 divisions on crosslines
H5/5	5mm in 5 divisions in grid pattern
H7/7	7mm in 7 divisions in grid pattern
H10/100	10mm in 100 divisions in grid pattern

OPTICAL TERMINOLOGY

1. Field Number (F.N.) and Practical Field of View

The field number (F.N.) is referred to as the diaphragm size of eyepiece in mm unit which defines the image area of specimen. The diaphragm diameter actually seen through eyepiece is known as the practical field of view (F.O.V.) which is determined by the formula:

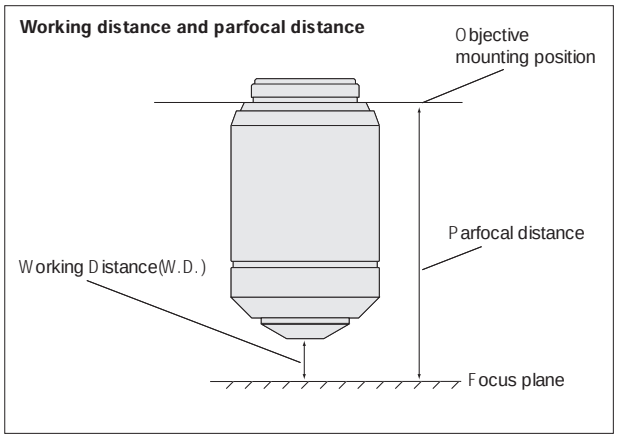
$$F.O.V. = \frac{\text{Eyepiece F.N.}}{\text{Objective lens magnification}} \text{ (mm)}$$

2. Working Distance (W.D.)

The distance between the front edge of the objective lens and the specimen surface (with the surface of the cover glass in case of the cover glass objective lens) when the specimen is focused.

3. Parfocal Distance

It is the distance between the objective lens mounting plane and the specimen. In UIS2/UIS objective lenses, the parfocal distance is designed at 45mm.



For parfocal distance of the LCPLFLN-LCD series objective lenses, refer to the objective lens page.

4. Relationship between the objective lens's focal length and magnifications

Indicated magnifications of UIS2/UIS objective lenses are the values when the focal length of the tube lens is 180 mm.

$$M_{(ob)} = \frac{\text{Focal length of tube lens}}{f}$$

$M_{(ob)}$: Objective lens magnification
f: Objective lens's focal length

5. Total Magnification

5.1 Observation through eyepiece (binocular observation)

$$M_{(bino)} = M_{(ob)} \times M_{(oc)}$$

$M_{(bino)}$: Total magnification for binocular observation
$M_{(ob)}$: Objective lens magnification
$M_{(oc)}$: Eyepiece magnification

5.2 Video monitor observation

● Total magnification for video monitor

$$M_{(\text{video monitor})} = M_{(ob)} \times M_{(\text{video camera adapter})} \times \text{Monitor magnification}^*$$

$M_{(\text{video monitor})}$: Total magnification on the video monitor
$M_{(ob)}$: Objective lens magnification
$M_{(\text{video camera adapter})}$: Projected magnification for video camera adapter including photo eyepiece
(refer to Figure 1)

**Refer to Figure 3 for "Monitor magnification"*

● Practical field of view for video monitor observation

$$\text{Practical field of view for video monitor observation} = \frac{\text{Image device size}^*}{M_{(ob)} \times M_{(\text{video camera adapter})}}$$

$M_{(ob)}$: Objective lens magnification
$M_{(\text{video camera adapter})}$: Projected magnification for video camera adapter including photo eyepiece
(refer to Figure 1 for projected magnifications)

**Refer to Figure 2 for image device size*

Figure 1 Video camera adapter and projection magnifications

Video camera adapter (Projection lens)	Projection magnifications
U-TV1x-1 + video camera mount adapters	1x
U-TV0.63xC	0.63x
U-TV0.5xC-3	0.5x
U-TV0.35xC-2	0.35x
U-TV0.25xC	0.25x

Figure 2 Imaging device size

Camera format	Diagonal	Horizontal	Vertical
1/3"	6.0mm	4.8mm	3.6mm
1/2"	8.0mm	6.4mm	4.8mm
2/3"	11.0mm	8.8mm	6.6mm

The above table is for standard image device sizes.
Check your device size for precise calculation.

Figure 3 Imaging device size and monitor magnifications

Camera format	Monitor size (diagonal)				
	9"	12"	14"	21"	27"
1/3"	38.1x	50.8x	59.2x	84.6x	114.1x
1/2"	28.6x	38.1x	44.5x	63.5x	85.7x
2/3"	20.8x	27.7x	32.3x	46.2x	62.3x

Example
What is total magnifications for video monitor when objective lens is 50x, video camera adapter U-TV0.5xC and 2/3" video camera are used ?

•Total magnification on the video monitor:
$m_{(ob)}$=50×, $M_{(video\ camera\ adapter)}$ is 0.5× from Figure 1 and monitor magnification is 46.2× from Figure 3.
$M_{(monitor\ observation)}=M_{(ob)}\times M_{(video\ camera\ adapter)}\times$monitor magnification
=50×0.5×46.2=1155×

•Practical filed of view for video observation(horizontal side):
$M_{(ob)}$=50×, $M_{(video\ camera\ adapter)}$ is 0.5× from Figure 1 and horizontal side of 2/3" imaging device is 8.8mm from Figure 2

$$\text{Practical field of view for video observation} = \frac{\text{Image device size}}{M_{(ob)} \times M_{(video\ camera\ adapter)}}$$

$$= \frac{8.8\ (mm)}{50 \times 0.5} = 352\mu m$$

6. Numerical Aperture (N.A.)

The numerical aperture is a key factor to the performance of objective lens (resolving power, focal depth and brightness).
The N.A. is determined by the following formula:

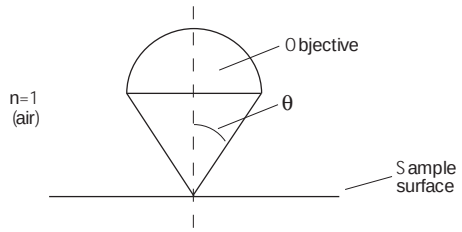
$$N.A. = n \times \sin\theta$$

n=Refraction rate of the medium between specimen and objective lenses. (Air: n=1, oil: n=1.515)
θ: Angle which is made by the optical axis and refraction of the light farthest from the center of the lens.

The visual field brightness (B) of the microscope is determined by the following formula in relation to the objective lens magnification (M). The larger the N.A. and the lower the objective magnification, brightness will increase in the factor of the second power.

$$B \propto \frac{N.A.^2}{M^2}$$

Numerical aperture



7. Resolving Power

The resolving power of an objective lens is measured by its ability to differentiate two lines or points in an object. The greater the resolving power, the smaller the minimum distance between two lines or points that can still be distinguished. The larger the N.A., the higher the resolving power.

● Resolving power formula
The following formula is generally used for determing resolution.

$$\varepsilon = 0.61 \times \frac{\lambda}{N.A.}$$ (Reyleigh formula)

λ: Wavelength or radiation in use
(λ=0.55μm is used for visible light)
N.A.: Objective lens N.A.

Example
MPLFLN100× (N.A.=0.90), λ=0.55μm

$$\varepsilon = 0.61 \times \frac{\lambda}{N.A.} = \frac{0.3355}{N.A.} = \frac{0.3355}{0.90} = 0.37\mu m$$

8. Focal depth of Microscope

The focal depth refers to the depth of the specimen layer which is in sharp focus at the same time, even if the distance between the objective lens and the specimen plane is changed when observing and shooting the specimen plane by microscope. As human eyes are individually different in the ability of their focus adjustment, each person's perception of the focal depth varies.
At present, the Berek formula is generally used, because it gives a focal depth value that often coincides with that obtained through experiments.

Focal depth formula

● Visual observation (Berek formula)

$$\pm D.O.F. = \frac{\omega \times 250,000}{N.A. \times M} + \frac{\lambda}{2\,(N.A.)^2}\ (\mu m)$$

D.O.F.: Depth Of Focus

ω: Resolving power of eyes 0.0014
(when optical angle is 0.5 degrees)
M: Total magnification
(objective lens magnification x eyepiece magnification)

$$\rightarrow \pm D.O.F. = \frac{350}{N.A. \times M} + \frac{0.275}{N.A.^2}\ (\lambda = 0.55\mu m)$$

This indicates that the focal depth becomes smaller as the numerical aperture becomes larger.

Example
With MPLFLN100× (N.A.=0.90), WHN10×:

$$\pm D.O.F. = \frac{350}{0.90 \times 1,000} + \frac{0.275}{0.81} = 0.39 + 0.34 = 0.73\mu m$$

● Video camera
In the case of a video camera, the focal depth will vary according to number of pixels of CCD, optical magnification, and numerical aperture. The above-mentioned formula is used as a rough guide only.

9. Aberrations

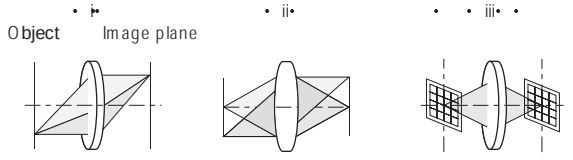
A difference between an ideal image and an actual image that passes through an optical system is called an "aberration."

9.1 Requirements for Ideal Image Formation

The following three requirements must be satisfied to form an image with no aberration, or an ideal image.

(i) All the light rays coming from a single point and passing through an image formation optical system converge on a single point.
(ii) Image points, which correspond to object points on the same plane perpendicular to the optical axis, are present on the same plane.
(iii) The planar shape of an object and the planar shape of an image that are on the same plane perpendicular to the optical axis have a similarity relation.

Figure 9-1 Requirements for Ideal Image Formation



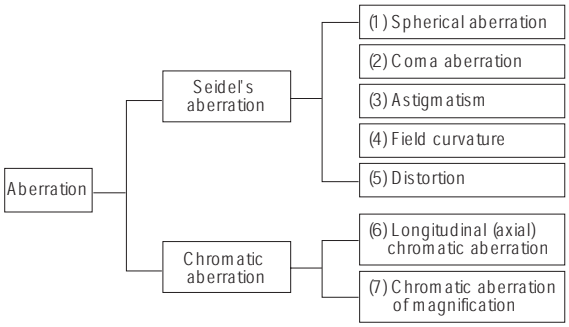
In an actual optical system, however, it is very difficult to strictly meet the requirements for ideal image formation and this causes "aberrations" that interfere with image forming performance.

9.2 Classification of Aberrations

Aberrations that interfere with image forming performance are classified as shown below in Figure 9-2.

Seidel's aberration = "Expansion of a point image" + "Curvature of image plane" + "Deformation"

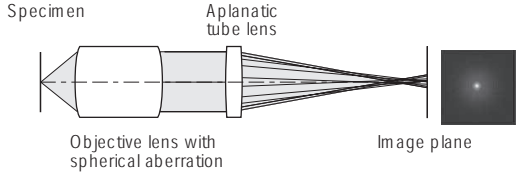
Figure 9-2 Classification of Aberrations



Types (1) to (3) correspond to "expansion of a point image" that goes against requirement (i) for ideal image formation in Figure 9-1. Type (4) corresponds to "curvature of image plane" that goes against requirement (ii) in Figure 9-1. Type (5) corresponds to "deformation" that goes against requirement (iii) in Figure 9-1. Types (6) and (7) correspond to "color blur" of images caused by characteristics of glass materials used for the optical system. "Expansion of a point image" can also be expressed by "wavefront aberration" that regards the light as "waves" and takes account of the phase to include the influence of diffraction.

(1) Spherical aberration
When light rays coming out of an axial object point enter a lens, the light rays with a larger numerical aperture (N.A.) are subjected to stronger refraction power and cross the optical axis in positions with larger differences from the ideal image formation position. The aberration caused this way by different image forming positions due to differences in N.A. of axial light rays is called "spherical aberration." ("Spherical aberration" is proportional to the cube of N.A.)

Figure 9-3 Spherical Aberration

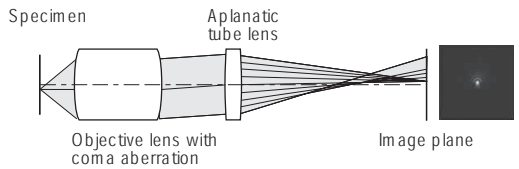


It is said that objective lenses with larger N.A. have better resolution but worsen spherical aberration. Our advanced design and manufacturing techniques have realized good optical performance even with large numerical aperture.

(2) Coma aberration

Even though spherical aberration is compensated to be very small, there are cases where light rays coming out of an off-axis object point are not condensed to a single point on the image plane but generate asymmetric blur just like a comet leaving traces. This is called coma aberration.

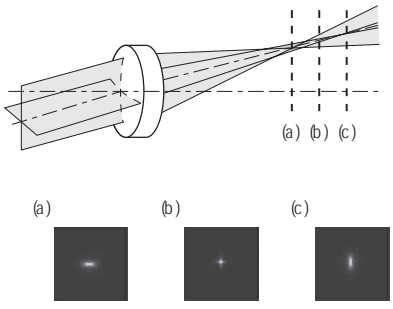
Figure 9-4 Coma Aberration and Spot Shape on the Image Plane



(3) Astigmatism

Even though a lens is compensated for spherical aberration and coma aberration, there are cases where an image of an off-axis object point is not focused to a single point but separated to a concentric line image and a radial line image. This is called "astigmatism." When astigmatism is present, a point image blurs vertically and horizontally, before and after the focus position.

Figure 9-5 Astigmatism and Change in Spot Shape in Different Focus Positions



(4) Field curvature

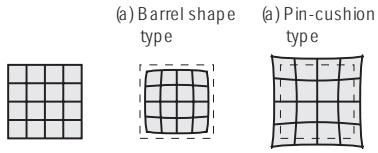
An image plane of an object on a plane perpendicular to an optical axis does not always become a plane perpendicular to the optical axis, but it generally becomes a curved plane. This symptom is called "field curvature."

When field curvature is present, the image is more displaced as it becomes closer to the periphery of the visual field. Therefore, when the center of an image is brought into focus, blur occurs in the peripheral areas of the image. To bring the entire image, including the periphery, into clear focus, it is necessary to adequately compensate for this type of aberration.

(5) Distortion

When there is no similar relation between a planar shape on an object and a shape on the image plane, this is called "distortion." When distortion is present, a square image appears in a shape of a barrel or pin-cushion as shown in Figure 9-6.

Figure 9-6 Distortion



The microscope optical system contains some distortion. When distortion is present, it can bring erroneous results of shape measurements. When a microscope is used for precision measurements, pay close attention to this aberration, for example, by providing it with an aberration compensation function.

(6) Chromatic aberration

Glasses used for optical systems have different refractive indexes depending on the wavelength. This causes differences in focal length between wavelengths and generates displacement of image forming position. This phenomenon is called "chromatic aberration," which is sometimes subdivided into axial displacement on the optical axis, called "axial chromatic aberration" (or lateral chromatic aberration) and displacement on the image plane, called "chromatic
aberration of magnitude."

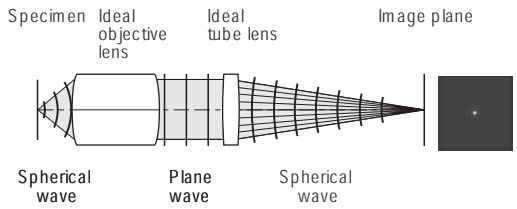
Many special glass materials are used, e.g., for apochromats (MPlanApo in Olympus), to eliminate chromatic aberration in a wide range from violet light (g-rays with wavelength of 435 nm) to red light (c-rays with wavelength of 656 nm).

9.3 Wavefront Aberration

Since a long time ago, aberrations have been used in "geometric optics," which considers light as "light rays." Microscope optical systems are often used for observation of very small specimens at a wavelength level, and sometimes adopt "wave optics," which regards light as "waves" and handles the phase information, taking account of the influence of diffraction.

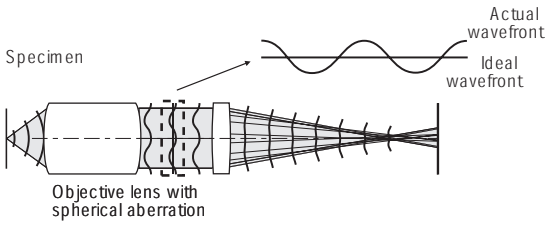
In such a case, "wavefront aberration" is used for evaluation. As shown below, when requirements for ideal imaging are satisfied in a microscope optical system, the spherical wavefront (spherical waves) coming from a single point on an object (specimen) is converted to plane waves through an ideal objective lens. The plane waves are converted to spherical waves through an ideal tube lens, and condensed to a single point. The wavefront of these waves is called the "ideal wavefront."

Figure 9-7 Ideal Microscope Optical System



Based on the figure indicated for (1) spherical aberration, the behavior of the wavefront in an optical system that has an aberration is described below.

Figure 9-8 Illustration of Wavefront Aberration



A difference (a degree of disagreement) between the ideal wavefront and the actual wavefront shown above is called "wavefront aberration."

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