Objectives for biological microscopes

The Ultimate in Optical Performance and System Flexibility

Nikon had two distinct goals in mind when creating its CFI60 optical system for advanced biological research microscopes:

1. To dramatically improve optical performance.
2. To boost overall flexibility of the microscope as a system and increase the performance when various microscope attachments and accessories are used.

To achieve this end, Nikon created a completely new standard for its CFI60 objectives.

By using a tube lens focal length of 200mm and objectives having a parfocal distance of 60mm with a larger diameter by using a thread size of 25mm, Nikon succeeded in realizing both higher NA and longer working distances than ever before.

In these revolutionary optics, both axial and lateral chromatic aberration have been corrected independently in the objective and the tube lens to produce flat images with excellent color reproduction, without the aid of other components.

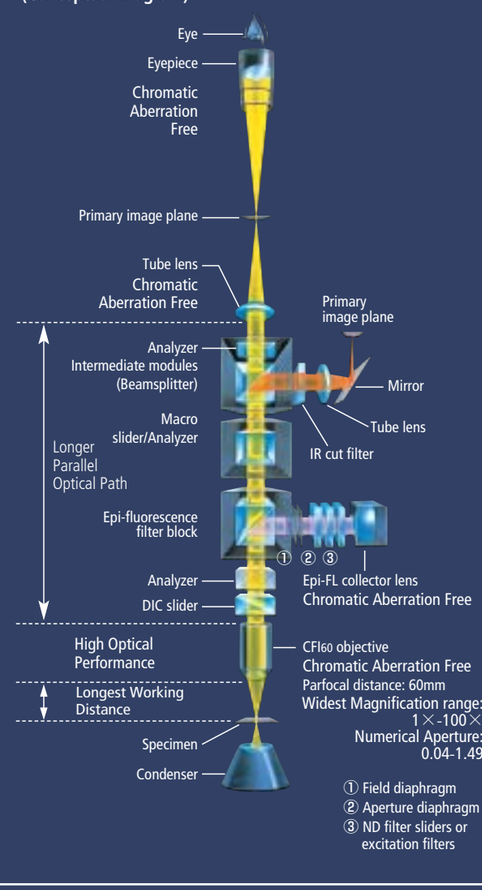
The 200mm tube lens creates a smaller angle between light rays passing through the center and those off axis.

This minimizes shifts between the two light rays when passing through the fluorescence filter cube and DIC prism, dramatically improving contrast during DIC and epi-fluorescence microscopy.

Nikon also designed objectives that curtail auto-fluorescence and flair to create greater contrast during epi-fluorescence observations.

With an array of innovative features, Nikon's CFI60 optical system delivers top-notch performance, enabling their use in increasingly sophisticated biological research.

CFI60 Optical Path
(Conceptual Diagram)



CFI60

New Series of Objectives Created with Nikon's Accumulated Optical Technologies

CFI Apochromat TIRF Series

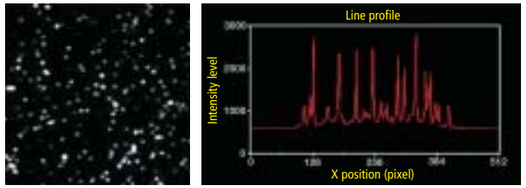
Objectives with an unparalleled NA of 1.49

- Because of the unprecedented NA of 1.49—for use with a standard coverslip and immersion oil—these objectives enable the acquisition of bright, high S/N ratio images; so they are suitable for TIRF observation and live cell imaging.
- Both the 60x and 100x lenses utilize the spherical aberration correction ring to reduce deterioration in image quality caused by deviations in cover glass thickness or temperature fluctuations and provide optimal optical performance even at 37°C.
- High NA and correction ring allow acquisition of high-resolution, high S/N ratio images during TIRF observation, episcopic or confocal fluorescence observation as well as Nomarski DIC observation.
- The 100x objective can be optimally applied for laser tweezers microscopy.

CFI Apo TIRF 60x oil, NA 1.49
CFI Apo TIRF 100x oil, NA 1.49

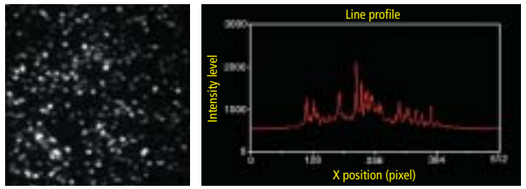
Much higher S/N ratio than a conventional model
Sample: Q-Dot

Apo TIRF 100x oil, NA 1.49 (new product)



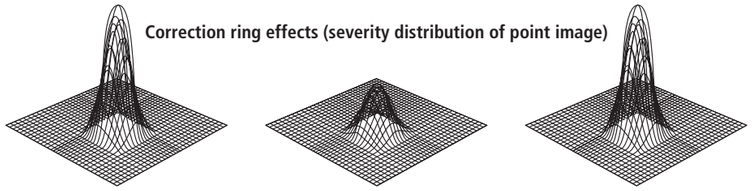
TIRF image — Intensity distribution of fluorescence signal

Plan Apo TIRF 100x oil, NA 1.45 (conventional product)



TIRF image — Intensity distribution of fluorescence signal

Correction ring effects (severity distribution of point image)



23°C — 37°C (no correction) — 37°C (with correction)

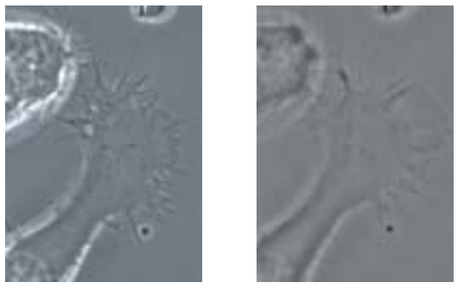
High-sensitivity Apodization Objective for Phase Contrast

Contrast doubled by reduction in halo

- The employment of an apodization phase ring reduces halo, which lowers the quality of phase contrast images. This improves the contrast of images to twice that achieved by a conventional product. This lens enables high-resolution observation of the minute structure in an unstained, low-contrast intracellular structure.
- With its high NA, this lens is also suitable for fluorescence observation.
- This lens is suitable for observation of the unstained structure and organelle of cultured cells as well as time-lapse observation of mitochondrial transport, growth cone and stress fiber.

CFI Plan Fluor ADH 100x oil, NA 1.30

Comparison with a conventional phase contrast objective lens



NG108-15 cell captured by CFI Plan Fluor ADH 100x oil objective.

The same cell captured by conventional phase contrast objective (CFI Plan Fluor DLL 100x oil).

Images: from The 29th Optics Symposium (2004, Tokyo) 43-46
Cooperation: Dr. Kaoru Kato, Neuroscience Research Institute, The National Institute of Advanced Industrial Science and Technology (AIST)

References: Kaoru Kato, Tatsuro Ohtaki, Motohiro Suzuki (2004) Biophysics Vol 44, No 6, 260-264

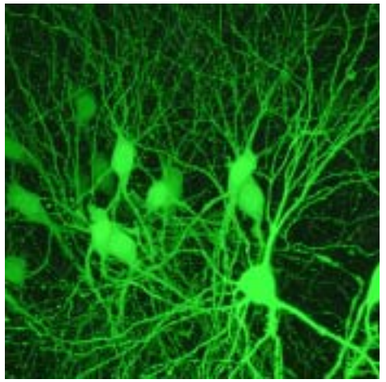
CFI Plan Apochromat VC Series

Essential for confocal observation such as DAPI

- Top performance objectives with perfect correction of chromatic aberrations in the visible light range and excellent resolution throughout the view field.
- Perfect choice for multi-stained, fluorescence specimens and for brightfield and DIC observation.
- In addition to the correction range of the conventional Plan Apochromat series (435–660nm), axial chromatic aberration has been corrected up to the violet range (405nm), making these objectives highly effective for confocal applications.
- Observation of images with excellent brightness throughout the view field by minimizing the light loss around the edges and increasing resolution—a critical criterion for digital-image capturing.
- The 60x water-immersion type features high spectral transmittance, even in the 360nm wavelength ultra-violet range, making it perfect for fluorescence observation of living organisms.

CFI Plan Apo VC 60x oil, NA 1.40
CFI Plan Apo VC 60x WI, NA 1.20
CFI Plan Apo VC 100x oil, NA 1.40
CFI Plan Apo VC 20x, NA 0.75 *New*

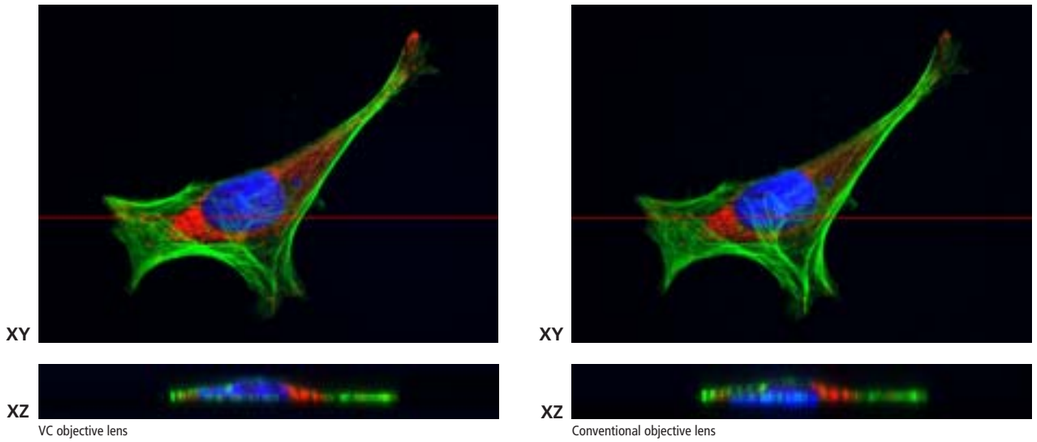
Water-immersion type CFI Plan Apo VC 60x WI objective is perfect for confocal observation of deep tissue



Overlaid consecutive cross-sectional scan within 108µm thickness range of a brain slice with neuronal cells expressing GFP.

Image courtesy of:
Professor Shigeo Okabe and Tatsuya Umeda, Department of Cell Biology, School of Medicine, Tokyo Medical and Dental University

Comparison of conventional lens and VC objective lens
With the conventional objective, DAPI fluorescence (blue) image may shift in the Z-axis direction due to axial chromatic aberration. With VC objective lens, on the other hand, as axial chromatic aberration has been corrected up to the violet range, DAPI fluorescence (blue) image shift in Z-axis direction is corrected and it is clearly seen that nucleus stained with DAPI is properly in a cell.



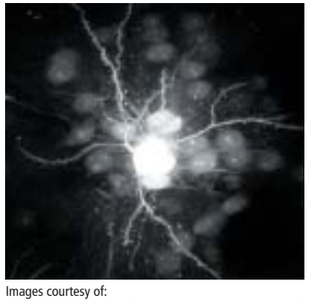
VC objective lens — Conventional objective lens

Fluorescence image of actin (green: Alexa 488, excitation: 488nm), mitochondria (red: Mito Tracker Organe, excitation: 543nm) and nucleus (blue: DAPI, excitation: 408nm) of HeLa cell. Consecutive cross-sectional XY and XZ images acquired with a confocal laser microscope and CFI Plan Apo VC 100x oil objective lens.

Water-immersion Objective Lens Series

New design for enhanced operability

- Long W.D. and high NA at any magnification.
- Sharper tips and broad approach angles provide improved accessibility for manipulator control.
- Aberrations are corrected even in the infra-red range with the high-magnification objectives, making them suitable for multi-photon imaging using infra-red light.
- 100xW objective with a correction ring that corrects spherical aberration induced by imaging depth or temperature fluctuations. With excellent infra-red transmission, this lens assures best quality images of even a thick specimen.



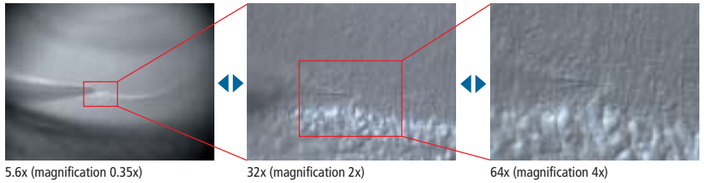
Images courtesy of:
Hiroyuki Hakozaki MS, Ellisman Laboratory, University of California, San Diego, Center for Research in Biological Structure, National Center for Microscopy & Imaging Research (NCMIR)

CFI Plan Fluor 10x W, NA 0.3, W.D. 3.5mm
CFI75 LWD 16x W, NA 0.8, W.D. 3.0mm
CFI Apo 40x W NIR, NA 0.8, W.D. 3.5mm
CFI Apo 60x W NIR, NA 1.0, W.D. 2.8mm
CFI Plan 100x W, NA 1.1, W.D. 2.5mm

Water-immersion objective lens with low magnification, high NA and long working distance CFI75 LWD 16xW

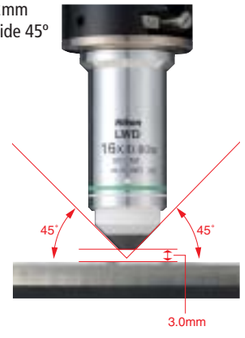
Single objective covers a wide range of magnifications

- The 16x objective lens, when combined with FN1 microscope and dedicated magnification module, provides 5.6x, 32x, and 64x magnifications. As it allows observation from a low magnification wide field to a high magnification high resolution field with single objective, the lens is ideal for patch-clamp experiments.
- With excellent IR transmission, this lens is also suitable for IR-DIC observation.
- With its high NA, the 16x objective provides superb image quality in combination with confocal laser microscopes
- Ultrawide field of view of 2mm (magnification 5.6x) and wide 45° approach angle make the manipulator control and positioning easy.



5.6x (magnification 0.35x) 32x (magnification 2x) 64x (magnification 4x)

Images courtesy of:
Dr. Hiroyoshi Miyakawa, Dr. Shigeo Watanabe, Tokyo University of Pharmacy and Life Science



16x objective can be used only in combination with a FN1 microscope and single objective holder.

CFI Apochromat λS Series

Ideal objectives for confocal imaging

- Fine correction of chromatic aberration and high transmission—enhanced with Nano Crystal Coating—cover a wide range of near-ultraviolet to near-infrared light.
- CFI Apo 40xWI λS has an NA of 1.25, the world's highest for a 40x water immersion objective.

Available soon

CFI Apo 40xWI λS, NA 1.25
CFI Apo LWD 40xWI λS, NA 1.15
CFI Apo 60xH λS, NA 1.4

Objectives for brightfield observation

CFI Plan Apochromat Series

This series features longer working distances with high NA and is designed to correct all optical aberrations throughout the visible spectrum from violet to red from center to edges across the entire 25mm field of view. Superior image flatness and color reproduction, plus resolving power at the theoretical limit of today's optical technology are also featured.

CFI Plan Fluor Series

Featuring an extra-high transmission rate, especially in the ultraviolet wavelength, and flatness of field, this series is designed for fluorescence observation and imaging. These objectives can function as multi-purpose objectives for brightfield, fluorescence, polarizing, and DIC observations.

CFI S Fluor Series

This CFI S Fluor series ensures a high transmission rate of ultraviolet wavelengths down to 340 nm for fluorochromes like indo-1, fura-2, and fluo-3. Also, these objectives have improved S/N ratios for short wavelengths and have high NA, making the fluorescence images they produce significantly sharper and brighter.

CFI Plan Achromat Series

Nikon's CFI Plan Achromat series provides incredible image flatness over the entire 25mm field of view, with chromatic aberration corrected throughout the entire visible spectrum. These objectives are suitable not only for observation but also for capturing images.

CFI Achromat Series

Correction of chromatic aberration, spherical aberration and coma has been dramatically improved, with significantly better image flatness across the 22mm field of view.

Objectives for advanced modulation contrast observation

CFI S Plan Fluor ELWD NAMC series

New

CFI Achromat NAMC series

Nikon Advanced Modulation Contrast

Nikon has developed dedicated objectives for advanced modulation contrast. Colorless and transparent samples can be observed in high relief with a plastic dish, which is not possible in DIC observation. The direction of contrast can be matched to S Plan Fluor ELWD NAMC objectives, thereby allowing optimal contrast selection for techniques like microinjection and ICSI.

Objectives for phase contrast observation

CFI Plan Apochromat Series for Phase Contrast

Correction for chromatic aberration has been improved and now extends across the entire visible spectrum to include the violet wavelength. High NA with longer working distances, comprehensive aberration correction, and superior flatness of field of view make these lenses ideal for the most demanding research projects.

CFI Plan Fluor Series for Phase Contrast

These objectives are multi-purpose; they can be used for brightfield, fluorescence, or phase contrast observations. They facilitate high-quality fluorescence observation and provide exceptionally detailed resolution of minute structures in phase contrast. The use of phase contrast to find the desired portion of the specimen before switching to fluorescence observation is an excellent way to minimize fluorescence photo bleaching.

CFI Plan Achromat Series for Phase Contrast

Nikon's CFI Plan Achromat series provides incredible image flatness over the entire 25mm field of view, with chromatic aberration corrected throughout the entire visible spectrum. With incredible image sharpness, these objectives can be used for laboratory work as well as exacting research.

CFI Achromat Series for Phase Contrast

Correction for chromatic aberration in this series has been dramatically improved and is now at the same level as the CFI Plan Achromat Series. These objectives now boast performance far outstripping their cost.

Objectives for apodized phase contrast observation

Apodized Phase Contrast Series

Nikon specifically developed this series for phase contrast observations by using its proprietary Apodization process to improve the objective's phase ring. Cell division activities taking place within a specimen—hitherto often obscured by unwanted halos—can now be observed more clearly.

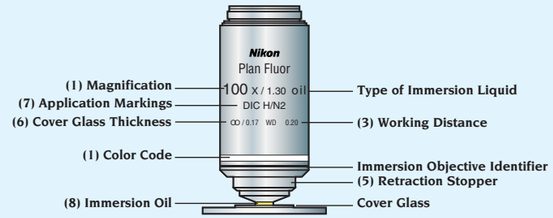
Objectives for inverted microscope Ti

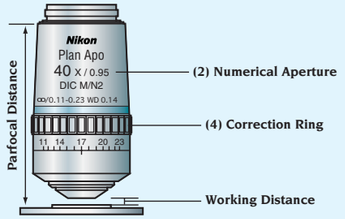
For brightfield observation

For phase contrast observation

CFI S Plan Fluor ELWD Series

Newly developed broadband multilayer coating realizes high transmittance from near-ultraviolet (Ca^{2+}) to near-infrared wavelengths, with improved chromatic correction. The correction collar ring allows these objectives to be used with a diverse range of culture vessels and specimen thicknesses. High-quality images with no aberrations can be obtained under a broad range of illumination techniques.





Nikon offers a wide variety of CFI objectives. To assist the user they are clearly marked with information on the objective barrel such as: which DIC module or Phase Ring to use.

(1) Magnification and Color Code

A color coded ring on the barrel identifies the magnification of the objective:

Mag.	1X	2X	4X	10X	20X	40X	50X	60X	100X
Color code	Black	Gray	Red	Yellow	Green	Light Blue	Light Blue	Cobalt Blue	White

(2) Numerical Aperture (NA)

NA is the most important factor in defining the performance characteristics of an objective.

NA = n sin θ

n: the refractive index of the media at d-line (587nm)

For dry objective n = 1.000 (air)

For oil immersion objective n = 1.515 (oil)

For water immersion objective n = 1.333 (water)

θ : Angle of half the cone of incident light that can enter or exit the top lens of the objective

The higher the NA, the higher the resolving power.

When the resolving power is defined as the power to distinguish the two points,

$$R = 0.61 \frac{\lambda}{NA}$$

If $\lambda = 0.55\ \mu m$ (Green light) and NA = 1.4,

resolving power (R) = $0.61 \frac{0.55}{1.4} = 0.24\ \mu m$

The higher NA the brighter image we take.

Brightness: $B \propto \left\{\frac{NA}{\text{Total Magnification}}\right\}^2$

The higher NA, the shallower the depth of focus (DOF).

$$DOF = \frac{n \lambda}{2NA^2}$$

(3) Working Distance

Working distance (W.D.) defines the distance between the top lens of the objective and the surface of the cover glass.

CFI60 objectives can offer longer working distance with high numerical aperture.

(4) Correction Ring

Dry objectives with high Numerical Aperture are susceptible to spherical and other aberrations which can impair resolution and contrast when used with a cover glass whose thickness differs from the specified value. A 1 1/2 cover glass (0.17mm thick) should be used as standard, however not all 1 1/2 cover glasses are exactly 0.17mm and many specimens have media between them and the cover glass. The correction ring is used to adjust for these subtle differences to ensure the optimum objective performance.

How to use the correction ring

- Position the ring at 0.17. The thickness of the standard cover glass is 0.17mm.
- Focus the lens on a small artifact in the specimen.
- Rotate the ring very slightly and focus the lens again to check if the image has improved or degraded.
- Repeat the above step to determine if the image is improving or degrading in the direction you are turning the ring.
- If the image has degraded, follow the same procedure in the opposite direction to find the position offering optimum resolving power and contrast.

(5) Retraction Stopper

Some objectives for oil immersion have a retraction stopper. In order to prevent clean slides from being accidentally smeared with immersion oil, the retraction assembly can be engaged by pushing in the front element and twisting it to the right. This will lock the objective in the up position so it will not leave immersion oil on a clean slide as the nosepiece is rotated. Twisting to the left will release the retracted objective for use.

(6) Cover Glass Thickness

For optimum performance, the thickness of the cover glass should be 0.17mm. For example, at NA = 0.95, a 0.01mm difference in thickness reduces image formation by 45% from the ideal image.

NA	Difference in cover glass thickness	
	0.01mm	0.02mm
0.3	100%	100%
0.45	100	100
0.7	98	92
0.85	81	43
0.95	45	29

(7) Application Markings

DIC: for differential interference contrast

DM: for phase contrast, dark contrast middle type

DL: for phase contrast, dark contrast light type

DLL: for phase contrast, lower contrast type

P: for polarizing

NCG: for use without cover glass

(8) Immersion Oil

After using immersion oil, gently blot the lens dry with lens tissue. Then slightly moisten a piece of lens tissue with petroleum benzene (Naphtha) and clean off all traces of the oil from the immersion objective. Cleaning is essential for water immersion objectives as well; after use, wipe the water off the top lens.

CFI60 Objectives

Type	Use	Model	Immersion	NA	W.D. (mm)	Cover glass thickness	Correction ring	Spring loaded	Brightfield	Darkfield	DIC	Phase contrast	Polarizing	Fluorescence		Ti-E PFS
														Visible light	UV	
Achromat	Brightfield (CFI)	4x		0.10	30.00	—			◎				△	○		
		10x		0.25	7.00	—			◎	△			△	○		
		LWD 20x		0.40	3.90	0.17			◎	○●			△	○		
		40x		0.65	0.65	0.17		✓	◎	○●			△	○		
		LWD 40xC		0.55	2.7-1.7	0-2.0	✓		◎	○●			△	○		
		60x		0.80	0.30	0.17		✓	◎	●			△	○		
		100xH	Oil	1.25	0.23	0.17		✓	◎				△	○		
		100xSH (with iris)	Oil	0.5-1.25	0.23	0.17		✓	◎	○●			△	○		
	Polarizing (CFI)	P 4x		0.10	30.00	—			◎				◎	○		
		P 10x		0.25	7.00	—			◎	△			◎	○		
		LWD P 20x		0.40	3.90	0.17			◎	○●			◎	○		
		P 40x		0.65	0.65	0.17		✓	◎	○●			◎	○		
		P 100xH	Oil	1.25	0.23	0.17		✓	◎				◎	○		
	Phase contrast (CFI)	DL 10x		0.25	7.00	—			○	△		◎ PH1	△	△		
		LWD DL 20x		0.40	3.90	0.17			○	○●		◎ PH1	△	△		
		LWD DL 20xF		0.40	3.10	1.2			○			◎ PH1	△	△		
		DL 40x		0.65	0.65	0.17		✓	○	○●		◎ PH2	△	△		
		LWD DL 40x		0.55	2.7-1.7	0-2.0	✓		○	○●		◎ PH2	△	△		
		DL 100xH	Oil	1.25	0.23	0.17		✓	○			◎ PH3	△	△		
		BM 10x		0.25	7.00	—			○			◎ PH1	△	△		
	Apodized phase contrast (CFI)	ADL 10x		0.25	6.20	1.2			○			◎ PH1	△	△		
		LWD ADL 20xF		0.40	3.10	1.2			○			◎ PH1	△	△		
		LWD ADL 40x F		0.55	2.10	1.2			○			◎ PH1	△	△		
		LWD ADL 40xC		0.55	2.7-1.7	0-2.0	✓		○	○●		◎ PH2	△	△		
	Advanced modulation contrast (CFI)	NAMC 10x		0.25	6.20	1.2			○					△		
		LWD NAMC 20xF		0.40	3.10	1.2			○					△		
		LWD NAMC 40xC		0.55	2.7-1.7	0-2.0	✓		○					△		
Plan Achromat	Brightfield (CFI Plan)	UW 1x		0.04	3.20	—			◎				△	△		
		UW 2x		0.06	7.50	—			◎				△	△		
		4x		0.10	30.00	—			◎				△	○		
		10x		0.25	10.50	—			◎	△			△	○		
		20x		0.40	1.20	0.17			◎	○●			△	○		
		40x		0.65	0.56	0.17		✓	◎	○●			△	○		
		50xH	Oil	0.90	NCG0.35	—		✓	◎	●			△	○		
		100xH	Oil	1.25	0.20	0.17		✓	◎				△	○		
	Phase contrast (CFI Plan)	DL 10x		0.25	10.50	—			○	△		◎ PH1	△	△		
		DL 20x		0.40	1.20	0.17			○	○●		◎ PH1	△	△		
		DL 40x		0.65	0.56	0.17		✓	○	○●		◎ PH2	△	△		
		DL 100xH	Oil	1.25	0.20	0.17		✓	○			◎ PH3	△	△		
	No cover glass (CFI Plan)	NCG 40x		0.65	0.48	0		✓	◎	○●			△	○		
		NCG 60x (CF objective)*2		0.85	0.35	0		✓	◎	●			△	○		
		NCG 100x		0.90	0.26	0		✓	◎	●			△	○		
	Super long WD (CFI L Plan EPI)	SLWD 20x		0.35	24.00	0			◎	○●			△	○		
		SLWD 50x		0.45	17.00	0			◎	○●			△	○		
		SLWD 100x		0.70	6.50	0			◎	○●			△	○		
S Plan Fluor*3	Brightfield (CFI S Plan Fluor)	ELWD 20xC		0.45	8.2-6.9	0-2.0	✓		◎	○●	○		○	◎	◎	●
		ELWD 40xC		0.60	3.6-2.8	0-2.0	✓		◎	○●	○		○	◎	◎	●
		ELWD 60xC		0.70	2.6-1.8	0.1-1.3	✓		◎	○●	○		○	◎	◎	
	Apodized phase contrast (CFI S Plan Fluor)	ELWD ADM 20xC		0.45	8.2-6.9	0-2.0	✓		○	○●		◎ PH1		○	○	●
		ELWD ADM 40xC		0.60	3.6-2.8	0-2.0	✓		○	○●		◎ PH2		○	○	●
		ELWD ADL 60xC		0.70	2.6-1.8	0.1-1.3	✓		○	○●		◎ PH2		○	○	
	Advanced modulation contrast (CFI S Plan Fluor)	ELWD NAMC 20xC		0.45	7.40	0-2.0	✓		○					○		
		ELWD NAMC 40xC		0.60	3.10	0-2.0	✓		○					○		
S Fluor*4	Brightfield (CFI S Fluor)	4x		0.20	15.50	—			◎				△	◎	◎ Wide	●
		10x		0.50	1.20	0.17		✓	◎	○●	○		△	◎	◎ Wide	●
		20x		0.75	1.00	0.17		✓	◎	○●	○		△	◎	◎ Wide	●
		40x		0.90	0.30	0.11-0.23	✓	✓	◎	●	○		△	◎	◎ Wide	
		40xH	Oil	1.30	0.22	0.17		✓w/stopper	◎		○		△	◎	◎ Wide	●
		100xSH (with iris)	Oil	0.5-1.3	0.20	0.17		✓	◎	○●			△	◎	◎ Wide	
Universal Plan Fluor	No cover glass polarizing (CFI LU Plan Fluor EPI)	P 5x		0.15	23.50	—			◎				◎	◎	◎	
		P 10x		0.30	17.50	0			◎	△			◎	◎	◎	
		P 20x		0.45	4.50	0			◎	○●			◎	◎	◎	
		P 50x		0.80	1.00	0		✓	◎	●			◎	◎	◎	
		P 100x		0.90	1.00	0		✓	◎	●			◎	◎	◎	

*1 Available soon *2 To use with the CFI60 optics microscope (not possible in E400), an objective conversion adapter is necessary.
*3 Axial chromatic aberration is corrected in shorter wavelength ranges than the Plan Fluor series to improve image clarity. *4 Transmits an ultraviolet light up to a 340nm wavelength
*5 Dedicated for FN1 (CFI75 objective)

Note 1. Model numbers
The below letters, when attached to the end of model numbers, indicate the respective features.

H: oil immersion type
F: for use with 1.2mm-thick cover glass
C: with correction ring
NCG: for use without cover glass
SH: with iris
WI: water immersion type
W: water dipping type
Mi: multi immersion (oil, water, glycerin) type

Note 2. Cover glass thickness
— : can be used without cover glass
0: use without cover glass

Note 3. Darkfield microscopy
Possible with the following
△ : universal condenser (dry) and darkfield ring
○ : above and darkfield condenser (dry)
● : darkfield condenser (oil)

Type	Use	Model	Immersion	NA	W.D. (mm)	Cover glass thickness	Correction ring	Spring loaded	Brightfield	Darkfield	DIC	Phase contrast	Polarizing	Fluorescence		Ti-E PFS
														Visible light	UV	
Plan Fluor	Brightfield (CFI Plan Fluor)	4x		0.13	17.10	—			◎				△	◎	◎	
		10x		0.30	16.00	0.17			◎	△	○		○	◎	◎	●
		20x		0.50	2.10	0.17			◎	○●	○		○	◎	◎	
		20xA MI	Oil, water, glycerin	0.75	0.51-0.35 0.51-0.34 0.49-0.33	0-0.17	✓	✓	◎	○●	○		○	◎	◎	
		40x		0.75	0.66	0.17		✓	◎	○●	○		○	◎	◎	●
		40xH	Oil	1.30	0.20	0.17		✓w/stopper	◎		○		○	◎	◎	●
		60x		0.85	0.40-0.31	0.11-0.23	✓	✓	◎	●	○		○	◎	◎	
		60xSH (with iris)	Oil	0.50-1.25	0.22	0.17		✓	◎	○●	○		○	◎	◎	
		100x		0.90	0.32-0.28	0.14-0.20	✓	✓	◎	●	○		○	◎	◎	
		100xH	Oil	1.30	0.20	0.17		✓w/stopper	◎		○		○	◎	◎	●
		100xSH (with iris)	Oil	0.50-1.30	0.20	0.17		✓	◎	○●	○		○	◎	◎	
	Phase contrast (CFI Plan Fluor)	DL 4x		0.13	16.40	1.2			○			◎ PHL		○	○	
		DLL 10x		0.30	16.00	0.17			○	△		◎ PH1		○	○	●
		DL 10x		0.30	15.20	1.2			○	△		◎ PH1		○	○	
		DLL 20x		0.50	2.10	0.17			○	○●		◎ PH1		○	○	
		DLL 40x		0.75	0.66	0.17		✓	○	○●		◎ PH2		○	○	●
		DM 40xDS		0.75	0.66	0.17		✓	○	○●		◎ PH2		○	○	
		DLL 100xH	Oil	1.30	0.16	0.17		✓w/stopper	○			◎ PH3		○	○	●
	Apodized phase contrast (CFI Plan Fluor)	ADH 100xH	Oil	1.30	0.16	0.17		✓w/stopper	○			◎ PH3		○	○	●
Plan Apochromat	Brightfield (CFI Plan Apo)	2x		0.10	8.50	—			◎				○	◎	△	
		4x		0.20	20.00	—			◎				○	◎	△	●
		10x		0.45	4.00	0.17			◎	△	○		○	◎	△	●
		20x		0.75	1.00	0.17		✓	◎	○●	○		○	◎	△	●
		VC 20x		0.75	1.00	0.17		✓	◎	○●	○		○	◎	△	●
		40x		0.95	0.16-0.12	0.11-0.23	✓	✓	◎	●	○		○	◎	△	●
		40xH	Oil	1.00	0.16	0.17		✓w/stopper	◎		○		○	◎	△	
		60x		0.95	0.17-0.13	0.11-0.23	✓	✓	◎	●	○		○	◎	△	
		VC 60xH	Oil	1.40	0.13	0.17		✓	◎		○	EXT PH3-60x	○	◎	△	●
		VC 60xA WI	Water	1.20	0.31-0.28	0.15-0.18	✓	✓	◎	●	○	EXT PH3-60x	○	◎	◎	●
		VC 100xH	Oil	1.40	0.13	0.17		✓	◎		○	EXT PH3-100x	○	◎	△	●
		NCG 100xH	Oil	1.40	0.16	0		✓	◎		○		○	◎	△	
	Phase contrast (CFI Plan Apo)	DM 20x		0.75	1.00	0.17		✓	○	○●		◎ PH2		○	△	
		DM 40x		0.95	0.16-0.12	0.11-0.23	✓	✓	○	●		◎ PH2		○	△	●
		DM 40xH	Oil	1.00	0.16	0.17		✓w/stopper	○	●		◎ PH3		○	△	
		DM 60x		0.95	0.17-0.13	0.11-0.23	✓	✓	○	●		◎ PH2		○	△	
		DM 60xH	Oil	1.40	0.13	0.17		✓	○			◎ PH3		○	△	●
		DM 100xH	Oil	1.40	0.13	0.17		✓	○			◎ PH3		○	△	●
Apochromat	Confocal (CFI Apo)	40xWI λS*1	Water	1.25	0.18	0.15-0.19	✓	✓	◎		○		○	◎	◎	●
		LWD 40xWI λS*1	Water	1.15	0.60	0.15-0.19	✓	✓	◎	●	○		○	◎	○	●
		60xH λS*1	Oil	1.40	0.14	0.17		✓	◎		○	EXT PH3-60x	○	◎	◎	●
	Evanescent (CFI Apo)	TIRF 60xH	Oil	1.49	0.12	0.13-0.19 (23℃) 0.15-0.21 (37℃)	✓		◎		○	EXT PH4-60x	○	◎	△	●
		TIRF 100xH	Oil	1.49	0.12	0.13-0.19 (23℃) 0.14-0.20 (37℃)	✓		◎		○	EXT PH4-100x	○	◎	△	●

Type	Use	Model	Immersion	NA	W.D. (mm)	Cover glass thickness	Correction ring	Spring loaded	Brightfield	Darkfield	DIC	Phase contrast	Polarizing	Fluorescence		Near-infrared DIC
														Visible light	UV	
Water Dipping	Brightfield (CFI Plan Fluor)	10xW	Water	0.30	3.50	0			◎	△	○		△	◎	◎	○
	Brightfield (CFI Fluor)	20xW	Water	0.50	2.00	0			◎	○●	○		○	◎	◎	○
		40xW	Water	0.80	2.00	0			◎	●	○		○	◎	◎ Wide	○
		60xW	Water	1.00	2.00	0			◎	●	○		○	◎	◎	○
	Brightfield (CFI Apo)	40xW NIR	Water	0.80	3.50	0			◎	●	○		△	◎	△	◎
		60xW NIR	Water	1.00	2.80	0			◎	●	○		△	◎		◎
	Brightfield (CFI Plan)	100xW	Water	1.10	2.50	0	✓		◎	●	○		△	◎		○
	Phase contrast (CFI Fluor)	DLL 40xW	Water	0.80	2.00	0			○	●		◎ PH2	△	○	○	○
	Brightfield (CFI75)	LWD 16xW*5	Water	0.80	3.00	0			◎	●	○		△	◎	○	○

Note 4. Phase rings are classified by objective NA
PHL: for Plan Fluor 4x
PH1: NA 0.25 - 0.5
PH2: NA 0.55 - 0.95
PH3: NA 1.0 - 1.40
PH4: NA 1.45 - 1.49
EXT: compatible with external phase contrast of the Ti series

Note 5. Fluorescence microscopy (UV)
△ : possible with visible light that has a longer wavelength than the excitation light used for DAPI
○ : suitable
◎ : recommended for best results
Wide: high transmittance with an ultraviolet wavelength range of up to 340nm

Note 6. Brightfield/DIC/Polarizing/Fluorescence (visible light) microscopy
△ : possible but not recommended
○ : suitable
◎ : recommended for best results

Note 7. Ti-E PFS
● : compatible with PFS (Perfect Focus System) of the Ti-E

⚠ WARNING	TO ENSURE CORRECT USAGE, READ THE CORRESPONDING MANUALS CAREFULLY BEFORE USING YOUR EQUIPMENT.

* Monitor images are simulated.

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Printed in Japan (0909-03)T

Code No. 2CE-MSSH-7

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