

# MICROSCOPE UNITS AND OBJECTIVES

(UV, NUV, VISIBLE & NIR REGION)



Wide range of microscope units and objective lenses lineup based on Mitutoyo's proprietary optical technologies and precision processing technologies cultivated over many years.

Used by customers around the world for a wide variety of applications.

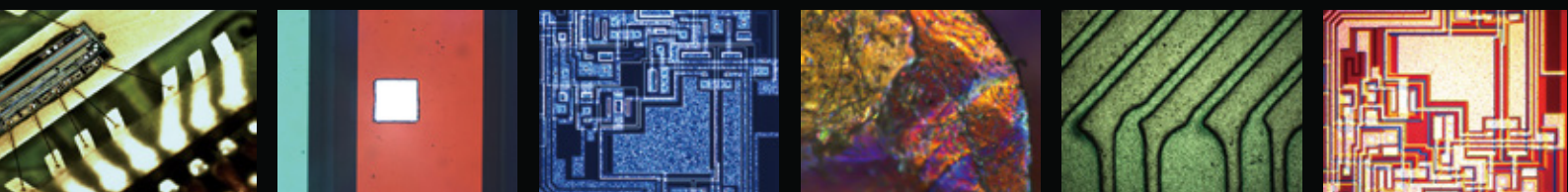
Applications : Production of semiconductors, electronics, liquid crystals, etc.

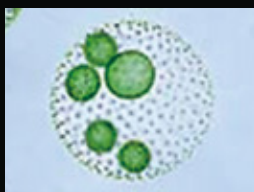
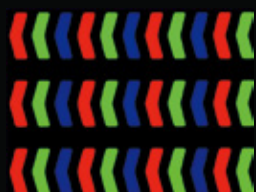
Optical systems for quality control systems and experimental research equipment

Built-in optical units for visual inspection systems

Observation of microorganisms and other moving objects

\* We also accept custom orders for products not listed in this catalog, so please feel free to contact us for more information.





Ref.: "Microbio-World Ver.7,"  
[http://elfe.miyakyo-u.ac.jp/opac/2008/03/cd\\_2.html](http://elfe.miyakyo-u.ac.jp/opac/2008/03/cd_2.html)



# Applications

## Optical inspection with wide field of view



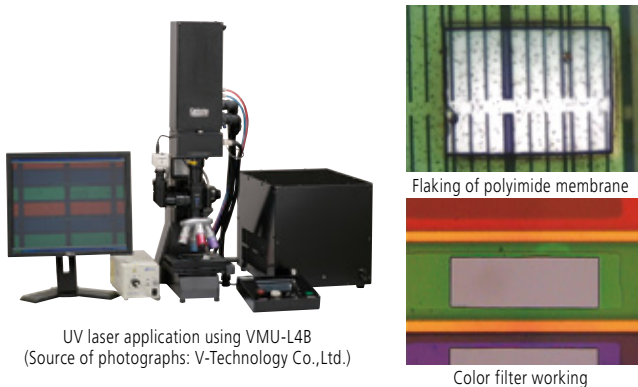
Lineup supporting various observation methods, including bright-field, dark-field, polarizing, differential interference, near infrared, high resolution, etc. Inspection process can be streamlined with wide field of view model.

## White light interference analysis



Compact design realizes non-contact high-accuracy fine surface shape analysis through white light interference.  
⇒ 3D shape measurement, 3D roughness measurement

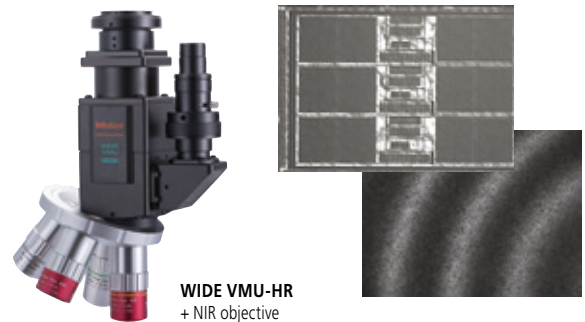
## Laser fine machining



Objectives compatible with YAG lasers (1064 nm, 532 nm, 355 nm and 266 nm) allow high precision and quality work.

- > Removal of protective films/organic films, etc.
- > Cutting of IC wiring (Au, Al) and exposure of lower layer pattern
- > Fine photomask and FPD repair, etc

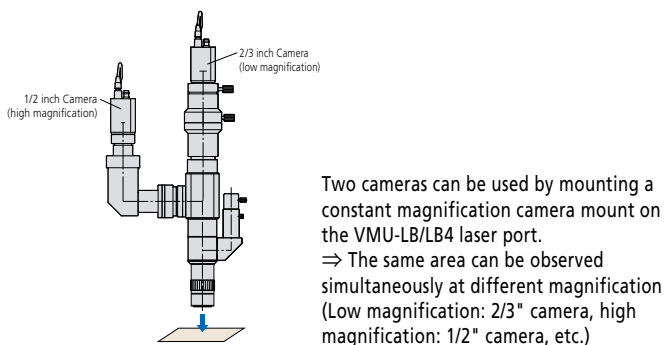
## IR analysis/inspection



Infrared analysis inspection is possible in combination with a microscope unit supporting NIR series objective lenses.

- > Transmission analysis of silicon materials
- > Non-destructive evaluation of MEMS interiors
- > Internal observation of semiconductor packages (IC)/wafer junction void evaluation
- > Infrared spectral characteristics analysis, etc.

## High/low magnification microscope (dual-camera)



## All-focus image generation



Ultra-high-speed focus range variation from low to high magnification lens, no mechanical vertical drive for focused images, arbitrary cross-section image acquisition possible.

\*For details, see the No. 14025 TAGLENS catalog





Find out more in our video:



<https://bcove.video/3Kp07QU>



You can download the CAD data, spectral transmission characteristics, and focal point on the image side data for each product.

For details, please check our website:

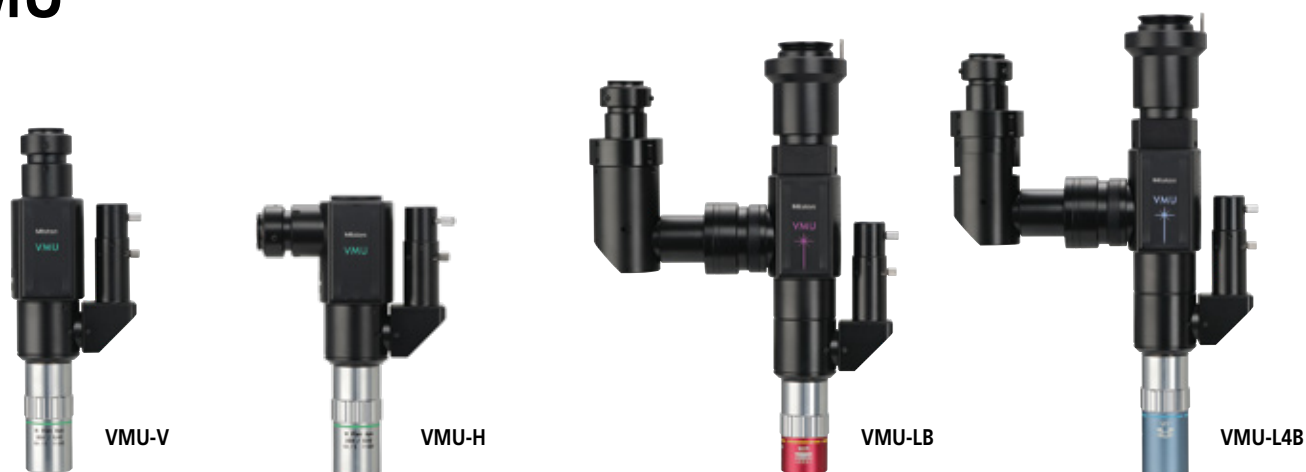


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# Microscope unit for incorporating in equipment

## VMU



Objectives shown mounted on tubes are optional.

### Features

- > Small, lightweight microscope unit
- > Compatible with infrared optical systems\*1
- > Custom-order is available to meet the customers' requirements\*3

\*1: An infrared source and infrared camera are necessary.

\*2: The performance and safety of laser-equipped system products is not guaranteed.

\*3: The design and manufacturing of the VMU series can be adapted to meet the customers' requirements: differential interference observation, dual camera setup (double magnification: high and low), etc.

### Features

- > Can be used with YAG (near-infrared, visible, near-ultraviolet, or ultraviolet) lasers.\*2 (Suitable for cutting, repairing and removing, and processing thin-film)
- > Models with enhanced rigidity and performance
- > Custom-order is available to meet the customers' requirements\*3

### Specifications

Model No.			VMU-V	VMU-H	VMU-LB	VMU-L4B
Code No.			378-505	378-506	378-513	378-514
Camera mounting orientation			Vertical	Horizontal	Vertical (rotatable)	
Observation			Bright-field/erect image	Bright-field/Inverted image	Bright-field/erect image	
Optical tube	Camera port	Optical features	Magnification: 1X; wavelength (λ): visible radiation			
		Mount	C-mount (centering and parfocal adjustment)			C-mount with centering and parfocal adjustment and green filter switch
	Tube lens (correction range)		Built in 1X (visible - NIR)		Built in 1X (NUV - NIR)	Built in 1X (UV - NIR)
	Laser port	Optical features	—		Magnification: 1X λ: 355/532/1064 nm	Magnification: 1X λ: 266/355/532/1064 nm
		Mount			YAG laser source (fundamental, second and third harmonic mode) available	YAG laser source (fundamental and second, third and fourth harmonic mode) available
					With parfocal adjustment	
Polarizer unit *1		Available for observation		Available for observation and laser applications		
Suitable objective (optional)		For observation	M Plan Apo, M Plan Apo HR (50X, 100X) M Plan Apo SL, G Plan Apo			
		For laser cutting	—		NIR series, NUV series	NIR series, NUV series, UV series
Applicable camera			2/3 inch or smaller			
Optical system epi-illumination			Telecentric with aperture diaphragm			
Illuminated lens tube			Bright-field illuminated lens tube			
Illumination unit (optional)			Fiber illumination unit (LED) (No.176-386), fiber-optic illumination unit (150 W) (No.176-316)			
Main unit mass			650 g	750 g	1270 g	1300 g

\*1: M Plan Apo 1X objective should be used together with a polarizer (378-710 or 378-715).

Note : Observe the following precautions when using VMU-LB or L4B with YAG laser source attached.

1. Be aware of the laser power and energy density. Otherwise, the optical system may be damaged.
2. Check the mass of the laser source. When mounting on a high-speed device or acceleration/deceleration device, please contact us.



WIDE VMU-HR



WIDE VMU-BDV



WIDE VMU-BDH

Objectives shown mounted on tubes are optional.

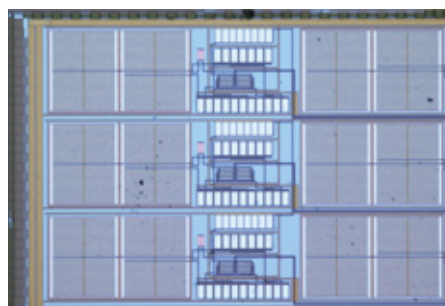
## Features

- > **Observation over a wide field of view** (image field of  $\phi 30$  mm)
- > **Compatible with HR series of high resolving power lens** (designed with pupil diameter of  $\phi 16.8$ )
- > **Greatly enhanced brightness on the periphery of the field of view** (reduces the dependence on the light distribution characteristics)
- > **Compatible with infrared optical systems**\*1
- > **Small optical observation system** (refer to page 9 for the dimensions)

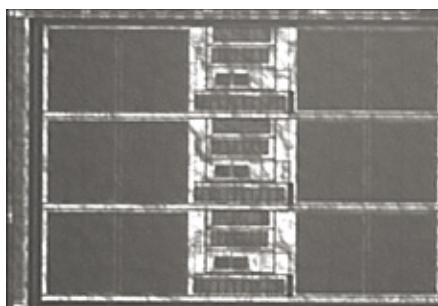
\*1: An infrared source and infrared camera are necessary.

## Features

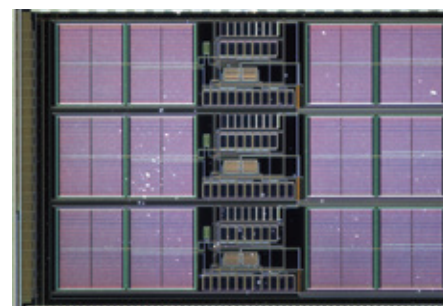
- > **Observation over a wide field of view** (image field of  $\phi 30$  mm)
- > **Supports dark-field observation suited to inspection for foreign objects and scratches** (instantaneous switching between bright-field and dark-field is possible with illumination light source on/off)
- > **Small design available**



Bright-field



Infrared



Dark-field

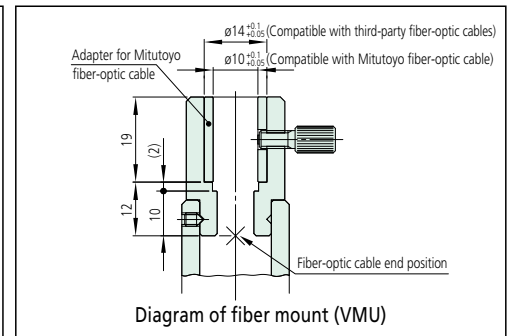
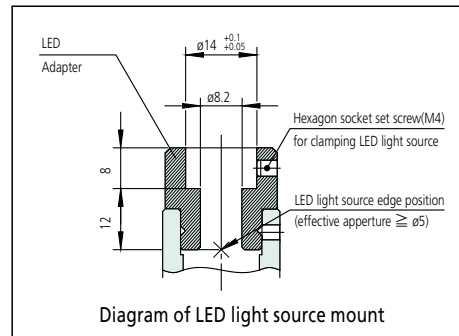
## Specifications

			For bright-field observation	For bright/dark-field observation	
Model No.			WIDE VMU-HR	WIDE VMU-BDV	WIDE VMU-BDH
Code No.			378-519	378-517	378-518
Camera mounting orientation			Vertical	Vertical	Horizontal
Observation			Bright-field/erect image	Bright/dark-field/erect image	Bright/dark-field/inverted image
Optical tube	Camera port	Optical features	Magnification: 1X Visible light - Near-infrared light	Magnification: 1X Visible light	
		Mount	F-Mount, C-Mount (with aligning and parfocal adjustment mechanism)		
	Imaging forming (tube) lens		Built in 1X (visible - NIR)	Built in 1X (visible)	
	Image field		ø30 mm		
	Polarized unit * <sup>1</sup>		Mountable		
Objective lens (required option)			M Plan Apo, M Plan Apo HR, M Plan Apo SL, G Plan Apo, NIR seriesBD Plan Apo		
Applicable camera			Diagonal line length: 30 mm or less (equivalent to APS-C format)		
Optical system epi-illumination			Telecentric (pupil diameter of ø16.8 with aperture diaphragm)	Telecentric illumination, bright/dark-field illumination optical tube (Dual-port fiber-optic illumination) Bright/Dark-field switching with light source on-off	
Illuminated lens tube			Bright-field illuminated lens tube (rotatable) * <sup>3</sup> LED adapter and fiber adapter included as standard	Bright-field illuminated lens tube (rotatable) * <sup>3</sup>	
Illumination unit (optional) * <sup>2</sup>			Fiber illumination unit (LED) (No.176-386), fiber-optic illumination unit (150 W) (No. 176-316)		
Main unit mass			1400 g	2000 g	2150 g

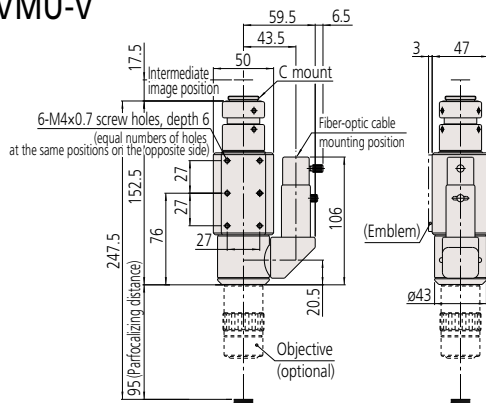
\*1: Polarized observation by bright-field illumination \*2: Support for third-party LED illuminators (WIDE VMU-HR only) \*3: The fiber (light source) mount orientation can be changed.



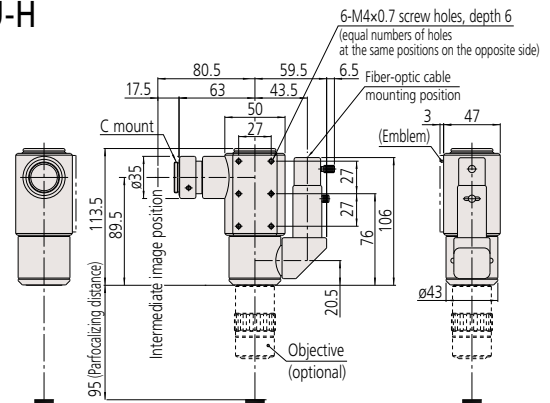
# VMU Dimensions



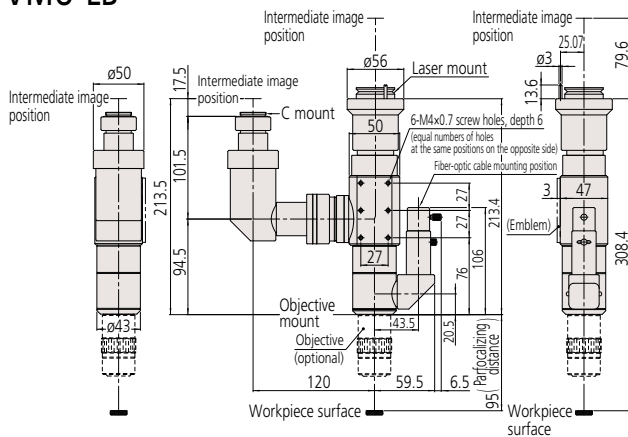
## VMU-V



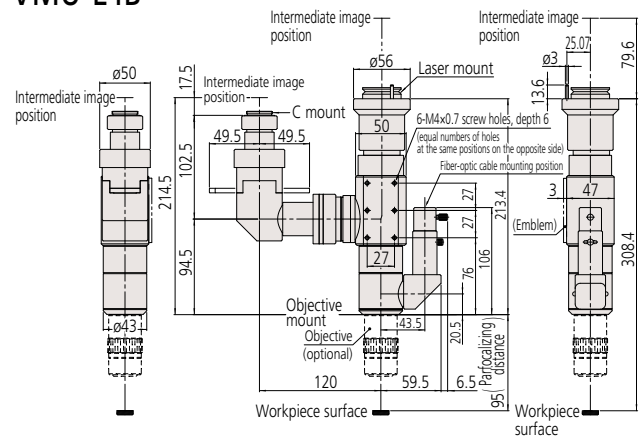
## VMU-H

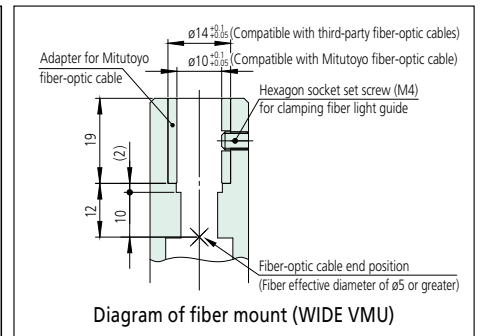
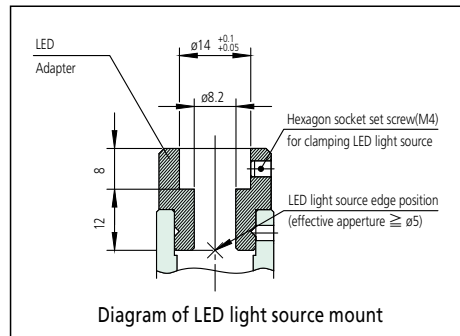


## VMU-LB

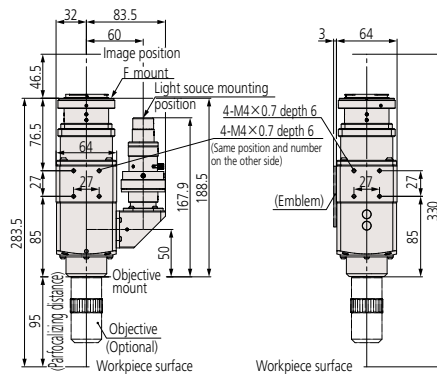


## VMU-L4B

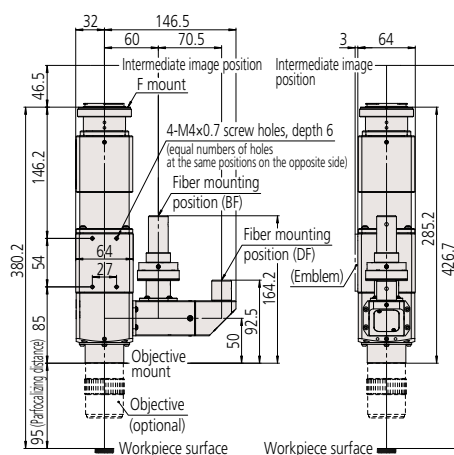




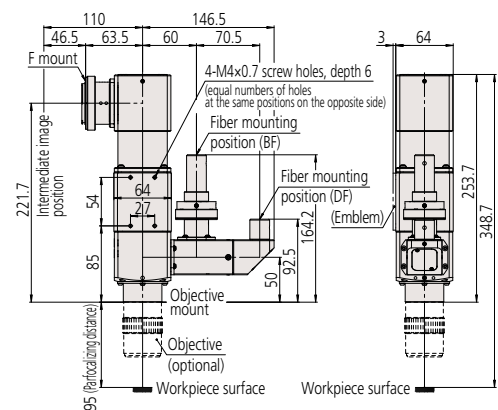
## WIDE VMU-HR



## WIDE VMU-BDV

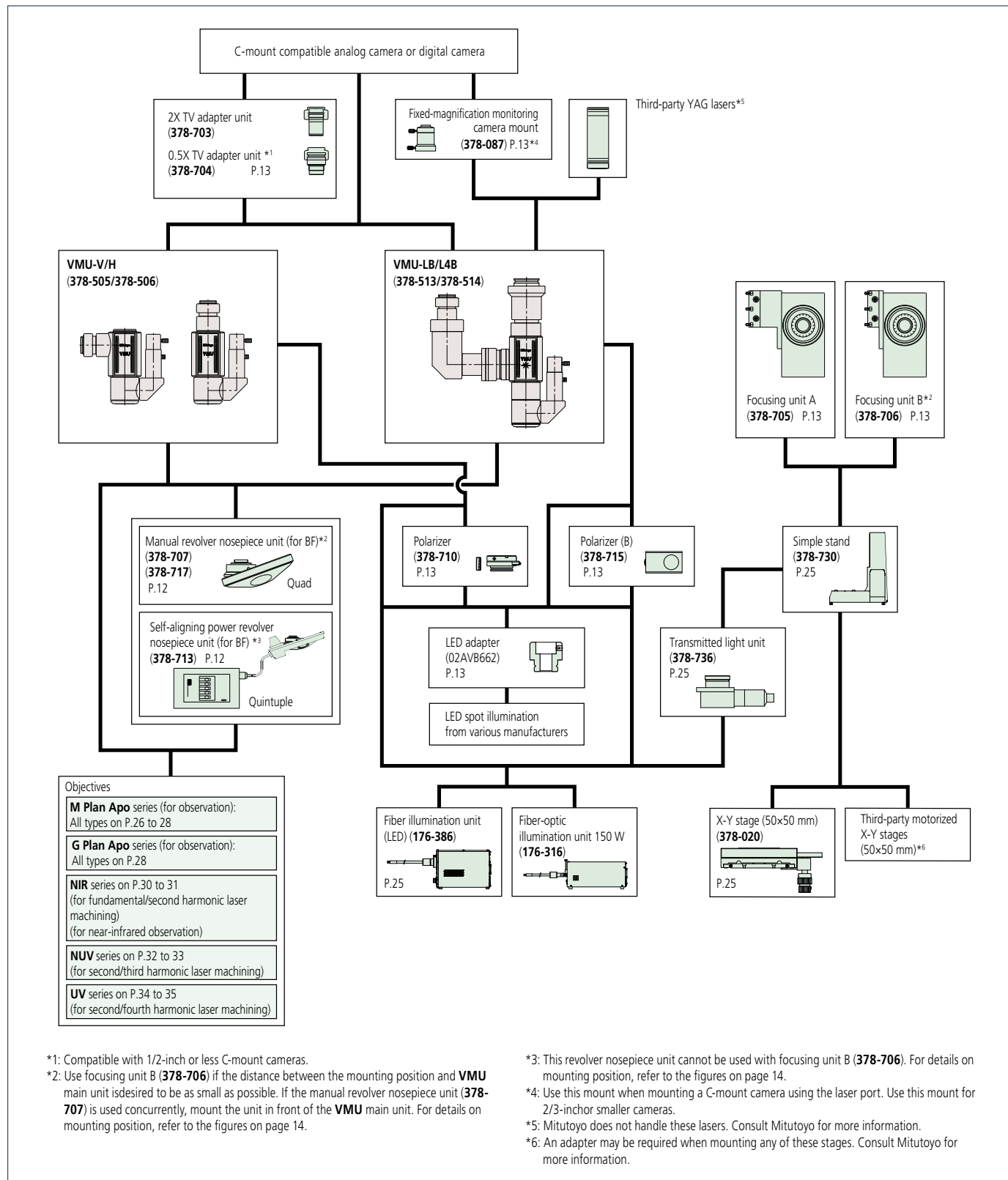


## WIDE VMU-BDH



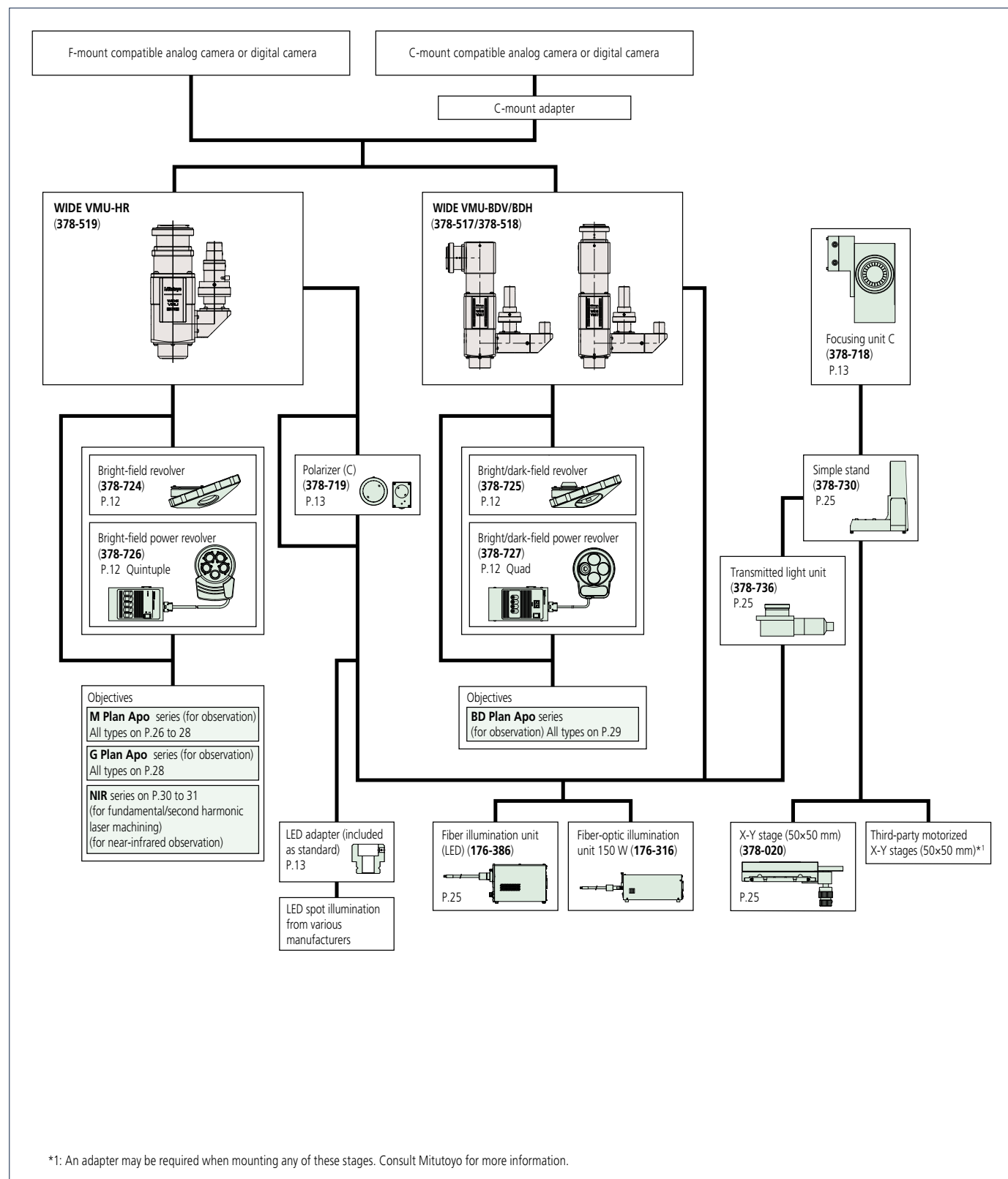
# VMU System Diagram

## VMU





## WIDE VMU



# Optional Accessories for VMU

## Manual revolver

Up to 4 objective lenses can be mounted.



No.378-724



No.378-725



Installed on 378-717 VMU-V  
with optional objectives



Installed on 378-724 WIDE VMU-HR  
with optional objectives

	Bright-field revolver			Bright/dark-field revolver
Code No.	378-707	378-717	378-724	378-725
Observation method	Bright-field			Bright/dark-field
No. of objective mounts	4 (reference hole)	4 (1 reference hole and 3 holes with centering and parfocal adjustment)	4 (reference hole)	4 (reference hole)
Mass	780 g	990 g	825 g	755 g
Applicable models	VMU-V, VMU-H, VMU-LB, VMU-L4B			WIDE VMU-BDV WIDE VMU-BDH

## Power revolver

Up to 5 objective lenses can be mounted on the bright-field power revolver.

Up to 4 objective lenses can be mounted on the bright/dark-field power revolver.



No.378-726



No.378-727



Installed on No.378-713 VMU-V  
with optional objectives



Installed on No.378-726 WIDE VMU-HR  
with optional objectives

	Bright-field power revolver		Bright/dark-field power revolver
Code No.	378-713	378-726	378-727
Observation method	Bright-field		Bright/Dark-field
No. of objective mounts	5 (1 reference hole and 4 holes with centering adjustment)		4 (Reference hole)
View field adjustment	$\pm 0.5$ mm		—
Positioning accuracy	$2\sigma = 3$ $\mu$ m		—
Durability (life-time)	1 million repositioning operations		—
Drive method	DC motor		—
Power supply	AC100 V - 240 V Max. power consumption is approx. 10 W		AC100 V - 240 V Max. power consumption is approx. 6 W
Output interface*1	RS-232C*1 for external PC control		
Cable length	2.9 m*2 (connection of power revolver and console box)		
Dimensions (WxHxD) and mass	Revolver: 130x47x186 mm, 1.8 kg, Console box: 108x63x176 mm, 810 g		Revolver: 164x65x137 mm, 1.8 kg, Console box: 108x72x193 mm, 810 g
Applicable models	VMU-V, VMU-H, VMU-LB, VMU-L4B		WIDE VMU-BDV, WIDE VMU-BDH

\*1: Optional RS-232C Cable: 12AAA807

\*2: The length of cable connecting the power revolver and console box is a safe maximum and therefore Mitutoyo does not guarantee error-free operation if a cable extension is used to increase total cable length.

## Focus unit

For manual focusing. With A and C mounted on a simple stand, the stand stage center and optical axis match.



Focus unit A mounted on WIDE VMU-V with an optional objective



Focus unit C mounted on WIDE VMU-HR with an optional objective

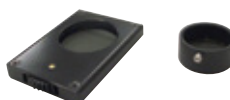
	Focus unit A	Focus unit B	Focus unit C
Code No.	<b>378-705</b>	<b>378-706</b>	<b>378-718</b>
Travel range	50 mm		
Coarse/fine feed	Coarse: 3.8 mm/rev., Fine: 0.1 mm/rev.		
Loading capacity	Approx. 17.4 kg	Approx. 17.7 kg	
Mass	2.9 kg	2.7 kg	
Applicable models	<b>VMU-V, VMU-H, VMU-LB, VMU-L4B</b>		<b>WIDE VMU-HR, WIDE VMU-BDV, WIDE VMU-BDH</b>

## Polarizer and analyzer

Provides simplified polarized light observation. Also enhances contrast of low-magnification objectives.



No.378-710



No.378-715



No.378-719

	Polarizer and analyzer		Polarizer and analyzer (C)
Code No.	<b>378-710</b>	<b>378-715</b>	<b>378-719</b>
Applicable models	<b>VMU-V, VMU-H</b>	<b>VMU-LB, VMU-L4B</b>	<b>WIDE VMU-HR, WIDE VMU-BDV, WIDE VMU-BDH</b>

## TV adapter unit

C-mount adapters for changing to a higher or lower magnification.

	2X TV adapter unit	0.5X TV adapter unit
Code No.	<b>378-703</b>	<b>378-704</b>
Magnification	2X	0.5X
Suitable camera	2/3 inch or smaller type	1/2 inch or smaller type
Mass	Approx. 25 g	
Applicable models	<b>VMU-V, VMU-H, VMU-LB, VMU-L4B</b>	



No.378-703



No.378-704

## Camera mount

Can be attached to the laser mount (VMU-LB and VMU-L4B) for dual-camera system.

	Camera mount
Code No.	<b>378-087</b>
Suitable camera	2/3 inch or smaller type (C-mount)
Mass	Approx. 180 g
Applicable models	<b>VMU-LB, VMU-L4B</b>

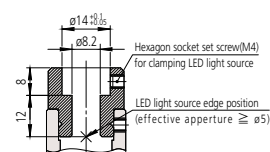


No. 378-087

## LED adapter

	LED Adapter
Code No.	<b>02AVB662</b>
Mass	Approx. 12 g
Applicable models	<b>VMU-V, VMU-H, VMU-LB, VMU-L4B</b>

\*For WIDE VMU, standard accessory.



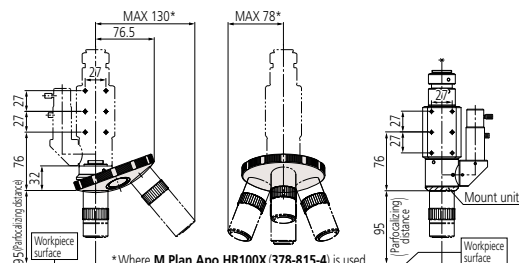
No. 02AVB662



# Dimensions of Optional Accessories for VMU

## Manual revolver

### Bright-field revolver (378-707/378-717)

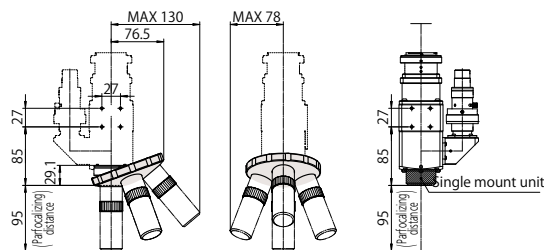


When mounting the revolver on **VMU-V** or **VMU-H**

Note 1: The lens mount must be removed from VMU.

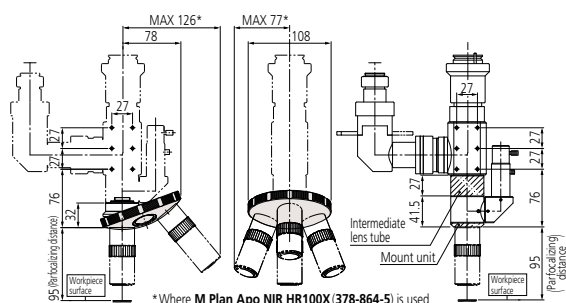
Note 2: The orientation of the revolver can be freely set to the mounting surface.

### Bright-field revolver (378-724)



Note 1: Revolver is installed by removing the single mount unit, but the distance between the mounting position of WIDE VMU main unit and the stage is unchanged.

Note 2: Revolver mounting direction is limited to the direction indicated in the figure above.

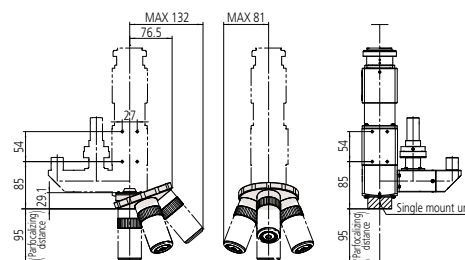


When mounting the revolver on **VMU-LB** or **VMU-L4B**

Note 1: The middle optical tube and lens mount must be removed from VMU.

Note 2: The orientation of the revolver can be freely set to the mounting surface.

### Bright/dark-field revolver (378-725)

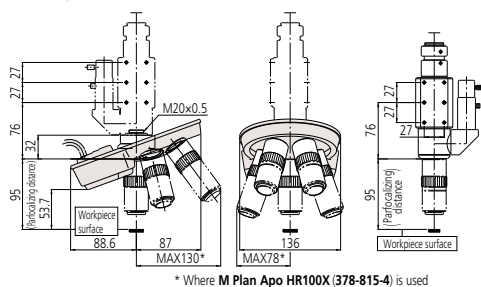


Note 1: Revolver is installed by removing the single mount unit, but the distance between the mounting position of WIDE VMU main unit and the stage is unchanged.

Note 2: Revolver mounting direction is limited to the direction indicated in the figure above.

## Power revolver

### Bright-field power revolver (378-713)

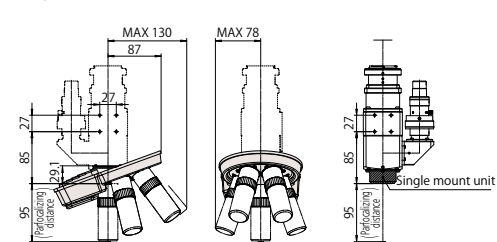


When mounting the revolver on **VMU-V** or **VMU-H**

Note 1: The lens mount must be removed from VMU.

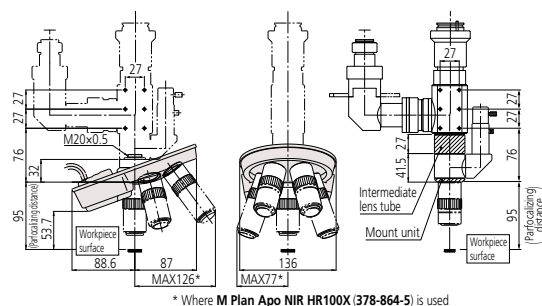
Note 2: The orientation of the revolver can be freely set to the mounting surface.

### Bright-field power revolver (378-726)



Note 1: Revolver is installed by removing the single mount unit, but the distance between the mounting position of WIDE VMU main unit and the stage is unchanged.

Note 2: Revolver mounting direction is limited to the direction indicated in the figure above.

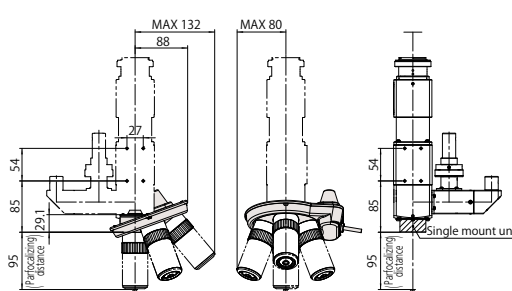


When mounting the revolver on **VMU-LB** or **VMU-L4B**

Note 1: The middle optical tube and lens mount must be removed from VMU.

Note 2: The orientation of the revolver can be freely set to the mounting surface.

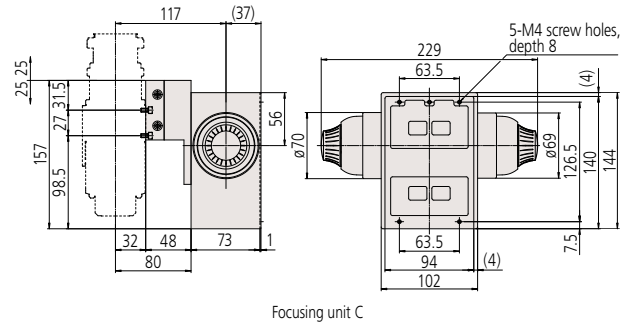
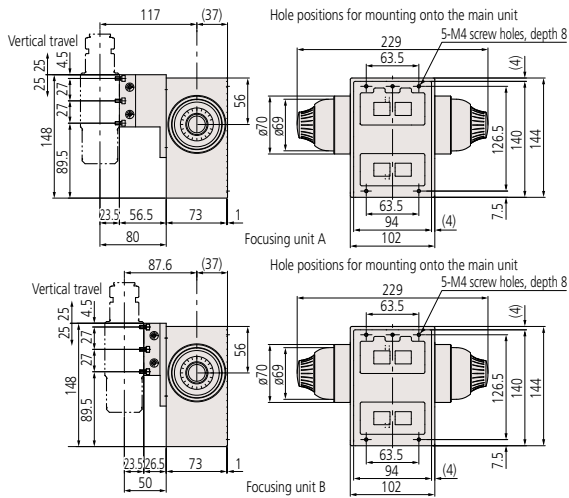
### Bright/dark-field power revolver (378-727)



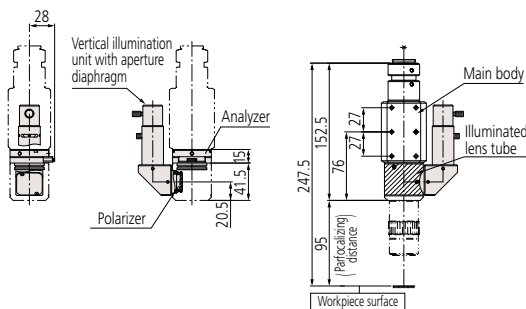
Note 1: Revolver is installed by removing the single mount unit, but the distance between the mounting position of WIDE VMU main unit and the stage is unchanged.

Note 2: Revolver mounting direction is limited to the direction indicated in the figure above.

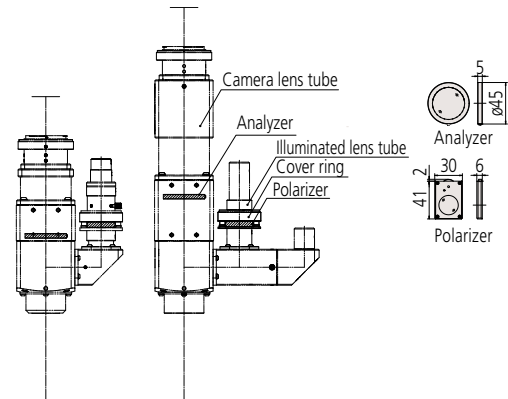
## Focus unit



## Polarizer and analyzer



## Polarizer and analyzer (C)

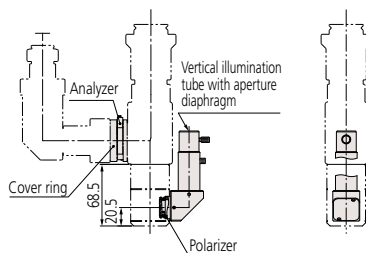


### Installing the polarizer and analyzer on VMU-V or VMU-H

Note: The analyzer is installed by removing the illuminated lens tube.

The polarizer is installed by removing the vertical illumination unit with aperture diaphragm.

Note: The polarizer is installed by loosening the cover ring.  
The analyzer is installed by removing the camera lens tube.

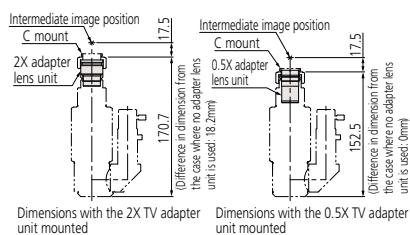


### When installing the polarizer on VMU-LB or VMU-L4B

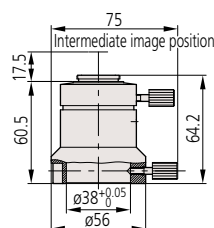
Note: The analyzer is installed by loosening the cover ring.

The polarizer is installed by removing the vertical illumination unit with aperture diaphragm.

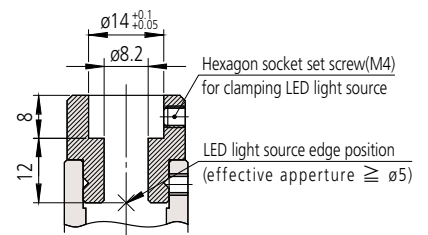
## TV adapter unit



## Camera mount



## LED adapter



# White Light Interference optical Unit WLI-Unit



Objectives shown mounted on tubes are optional.

## Features

- > **Non-contact high-accuracy fine surface texture measurement is possible through white light interference: 3D shape measurement, 3D roughness measurement.**
- > **Height measurement accuracy not dependent on optical magnification**  
Measurement enabled with high Z-resolution even with low-magnification lens
- > **High aspect ratio measurement**  
Supports high aspect ratio shape measurement through detection not dependent on optical-based NA
- > **High robustness with regard to disturbance vibration**
- > **Compact and lightweight**



## Specifications

Code No.		554-001	554-002	554-003
Model		WLI-Unit-003	WLI-Unit-005	WLI-Unit-010
WLI-Unit Sensor Head	Cable length (m)	3	5	10
	Applicable objective lens *Optional selection	WLI Plan Apo series		
	Tube lens magnification	1X		
	Focal range (f mm)	100		
	Scanning mechanism	Mitutoyo Objective Lens Scanner		
	Size/weight	108x68x191 mm / 1.7 kg		
WLI measurement (WLI-Unit-003/005/010 common)	Z motion range	8000 μm		
	Measurement mode	High throughput	Standard	High resolution
	WLI measurement Z range	2100 μm	1900 μm	1700 μm
	Throughput @20 μm range	3.0 s	4.0 s	6.0 s
	Z resolution	—	4 nm	
	Z repeatability (σ)	—	40 nm	
WLI-Unit Controller	I/F	WLI-Unit sensor head terminal/stop connector/GigaBit Ethernet: 2 ch		
	Rated voltage	AC100〜240 V / 50, 60 Hz		
	Max. power consumption	20 W		
	Size/weight	196x180x108 mm / 2.3 kg		
Software	WLIPAK	WLI-Unit control library (SDK), sample code, WLIPAK Sample GUI		
	WLI-Unit calibration SW	Pixel calibration		
	Analysis software (recommended option)	MCubeMap		
Other	Frame grabber/PC	Matrox frame grabber/PC separate		

### Recommended PC specifications

OS: Windows 10 Pro 64 bit/Windows 11 Pro 64 bit, CPU: Xeon Processor 8 Core (2.0 GHz or above), memory: 8 GB or above, storage: 25 GB or above, optical drive: DVD-ROM drive (for software installation), communication port: RJ-45  $\times$  1 port (EtherNET), extension slots: PCI Express 3.0  $\times$  8 or above

# Objective lens for white light interference measurement

## WLI Plan Apo

WLI-Unit

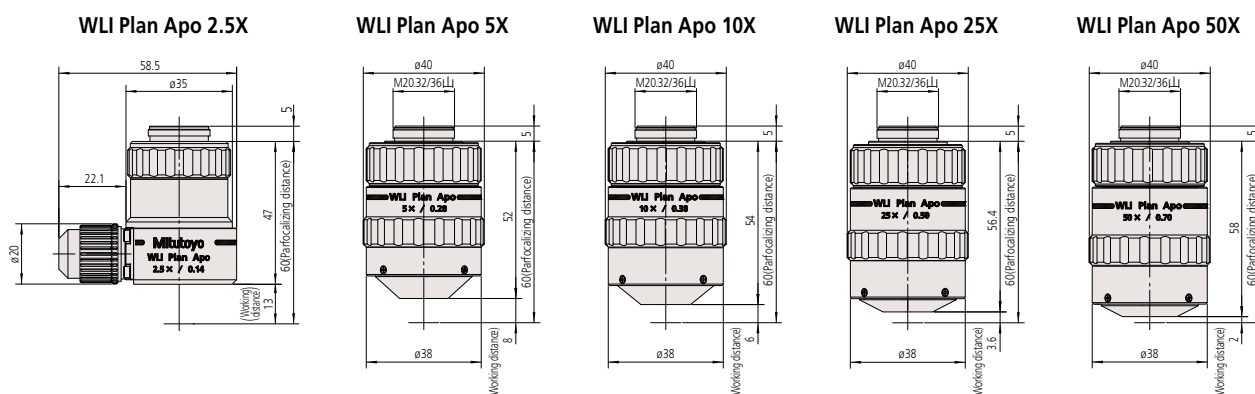


Scheduled for autumn 2024 release

### Features

- > New design matching the WLI-Unit
- > Ensures long working distance while more compact and lighter-weight (parfocal 60 mm)
- > High NA, high resolution
- > Plan apochromat
- > Beam splitter and reference mirror mounted inside objective lens
- > Interference fringe adjustment mechanism equipped as standard

### Dimensions



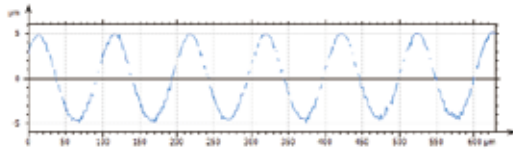
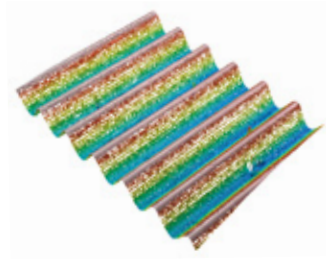
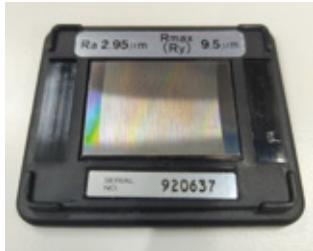
### Lens specifications

Model Code No.	N.A.	W.D. (mm)	f (mm)	R (μm)	Parfocalizing distance (mm)	FOV (mm)		Applicable tube lens f (mm)	Mirror tube length (excluding mounting screws)	Outermost diameter	Mounting screws	Mass (g)
						WLI-Unit	2/3 inch camera					
<b>WLI Plan Apo</b>												
WLI Plan Apo 2.5X 378-400	0.14	13.0	40	2.0	60	2.94x2.25	2.64x3.52	100	47	36.4 (excluding interference unit) 58.5 (Max)	RMS / 20.32 mm x36 TP	320
WLI Plan Apo 5X 378-005	0.28	8.0	20	0.98	60	1.46x1.12	1.32x1.76	100	52	40		210
WLI Plan Apo 10X 378-401	0.38	6.0	10	0.72	60	0.73x0.56	0.66x0.88	100	54	40		220
WLI Plan Apo 25X 378-402	0.50	3.6	4	0.55	60	0.29x0.22	0.26x0.35	100	57	40		290
WLI Plan Apo 50X 378-403	0.70	2.0	2	0.39	60	0.14x0.11	0.13x0.18	100	58	40		300

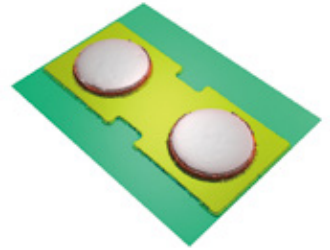
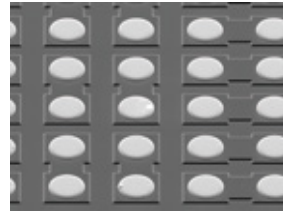
\*Resolution values in the specifications above are calculated based on reference wavelength ( $\lambda = 0.55 \mu\text{m}$ ).

# WLI Measurement Example

Roughness specimen 3  $\mu\text{m}$

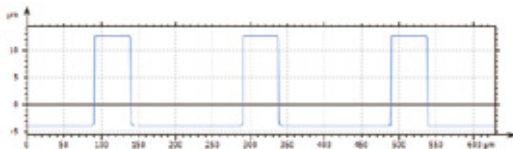
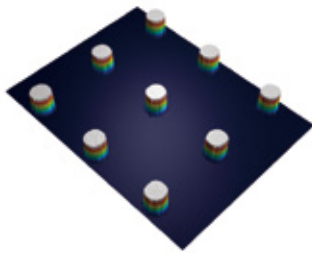
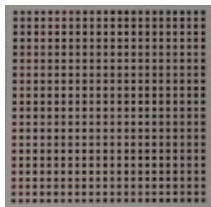


Semiconductor test pattern (TEG)

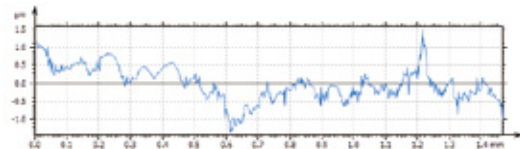
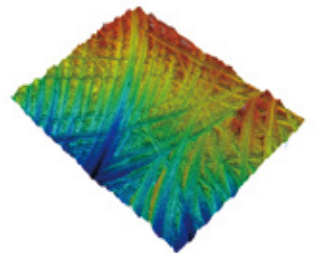


Provided by Walts Co., Ltd. and ASK INDEX

Cu pattern (glass substrate)

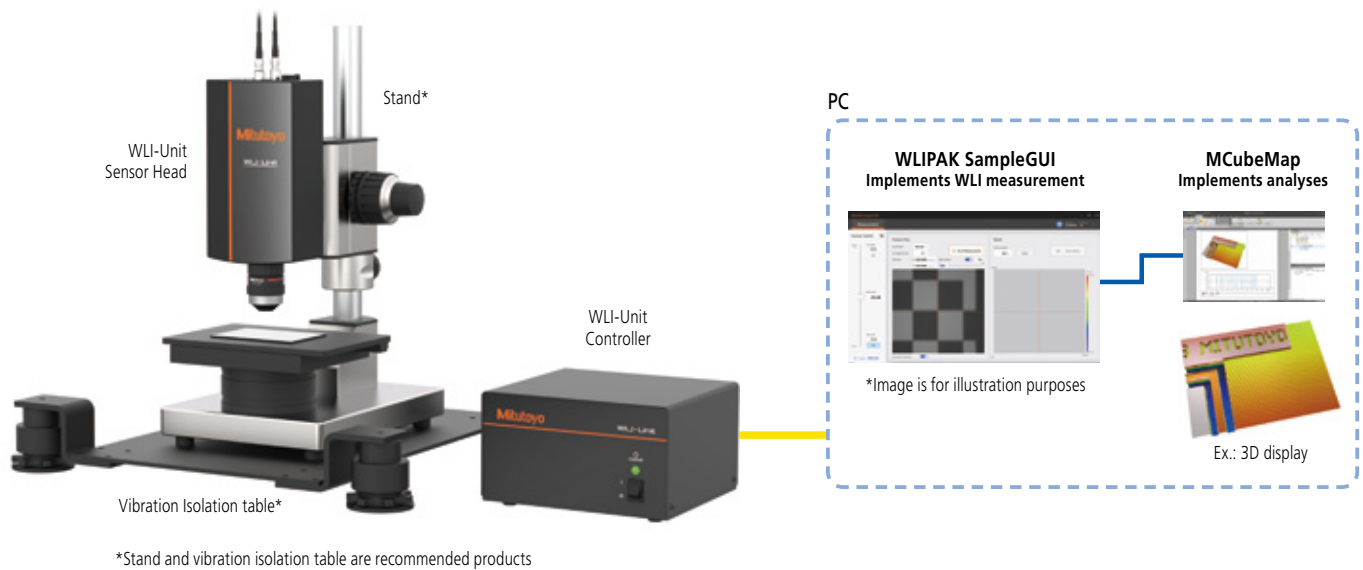


Metal machined surface (Aluminum)



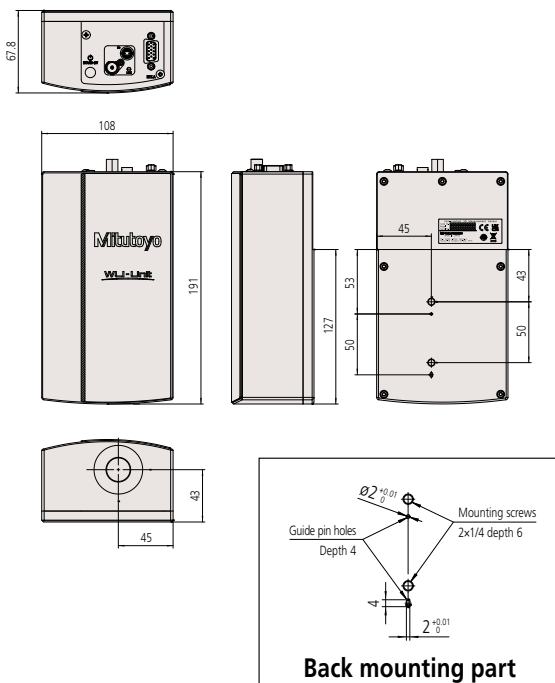


# WLI System Configuration (example with stand/motorized stage/vibration isolation table)

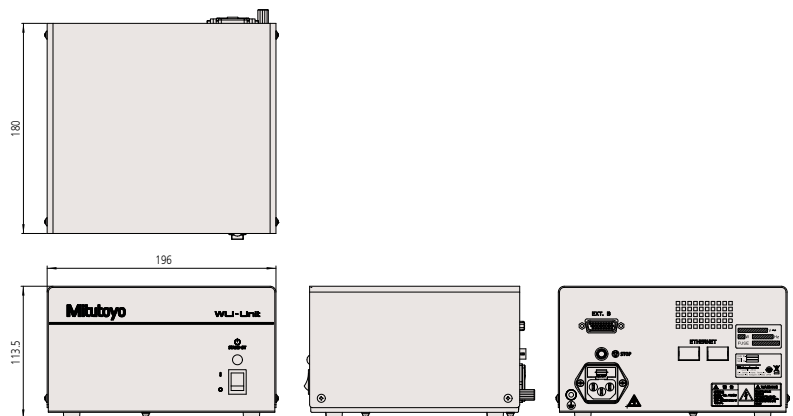


## Dimensions

### WLI-Unit Sensor Head



### WLI-Unit Controller



# Microscope unit FS70



FS70Z



FS70L



FS70L4

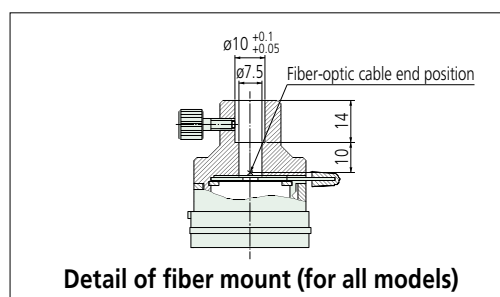
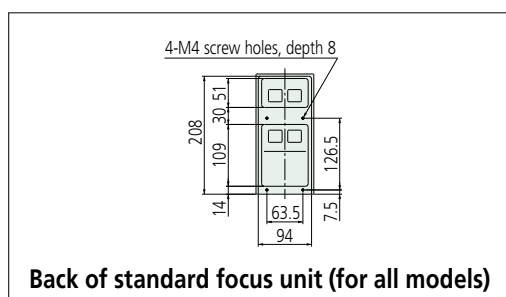
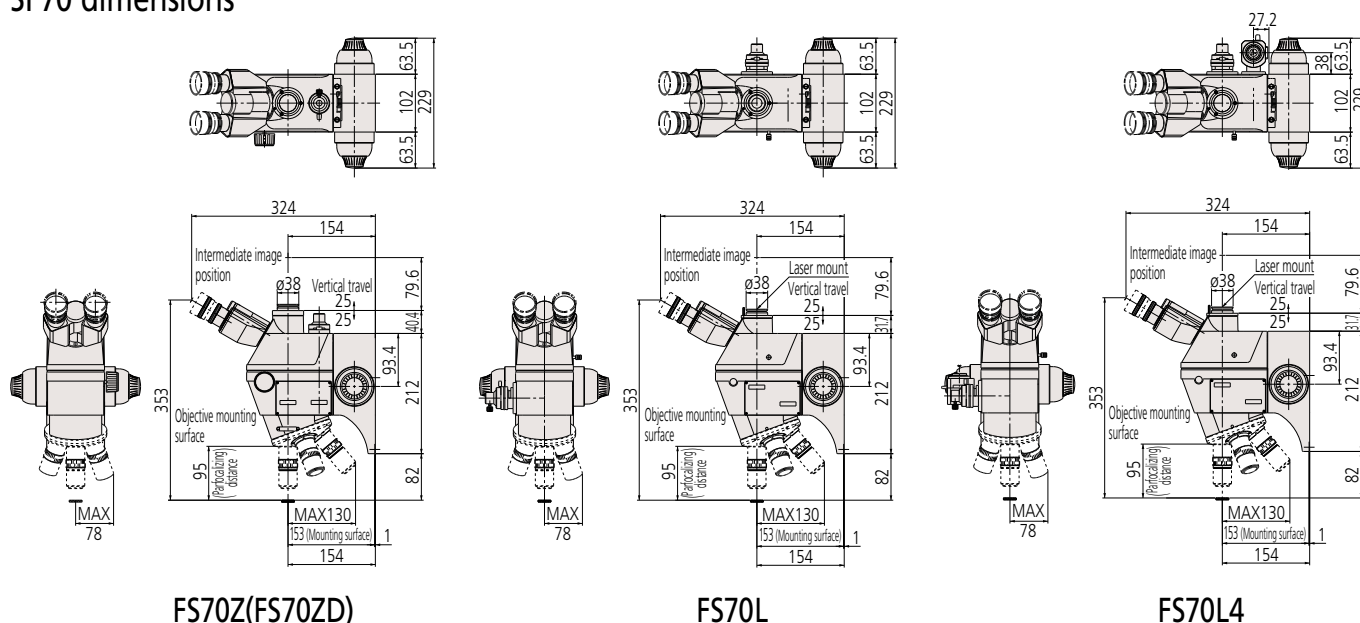
The eyepieces, revolver and objectives shown mounted are optional.

## Features

- > **Compact microscope unit with trinocular eyepiece tube**  
(Suitable for observation of many different types of object: metal surfaces, semiconductors, LCDs, resins, etc.)
- > **Can used with YAG (near-infrared, visible, near-ultraviolet, or ultraviolet) lasers.\*1**  
(Suitable for cutting, trimming, repair and marking of IC wiring (Au, Al), removing and processing thin-films (insulating film) and repair of color filters).
- > **Compatible with infrared optical systems\*2**

- > **Product range supporting various observation methods**  
(Bright-field/dark-field/simple polarization/differential interference contrast (DIC))
  - > **Equipped as standard with a Koehler illumination with aperture diaphragm for epi-illumination optical systems**
  - > **High operability with microscopes**  
(Inward revolver design and long-working-distance objectives)
- \*1: The performance and safety of laser-equipped system products is not guaranteed.  
\*2: An infrared source and infrared camera are necessary. For more details on infrared observation, contact your local Mitutoyo sales office.

## FS70 dimensions



## Specifications

Standard head type		Model No.	FS70		—		FS70Z		—		FS70ZD		FS70L		FS70L4	
		Code No.	378-184-1		—		378-185-1		—		Made-to-order		378-186-1		378-187-1	
Tilting head type		Model No.	—		FS70-TH		—		FS70Z-TH		FS70ZD-TH		FS70L-TH		FS70L4-TH	
		Code No.	—		378-184-3		—		378-185-3		Made-to-order		378-186-3		378-187-3	
Observation image			Erect image													
			BF (Bright-field)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
			BD(Bright-field/ Dark-field)								✓					
			Polarization	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
			Differential interference contrast (DIC)	✓	✓	✓	✓	✓	✓	✓	✓	✓				
Eyepieces (required option)			10X (field number 24) •15X (field number 16)• 20X (field number 12)													
Optical tube	Trinocular tube	Field number	24													
		Eye width adjustment	Siedentopf, adjustable interpupillary distance range: 51 - 76 mm													
		Tilt angle	0 to 20° (only for -TH), displacement of eye point: approx.114 mm													
		Optical pass ratio	Fixed type (Eyepiece/TV = 50/50)	Switchable type (Eyepiece/Tube = 100/0: 0/100)	Fixed type (Eyepiece/TV = 50/50)	Switchable type (Eyepiece/Tube = 100/0: 0/100)	Fixed type *1 (Eyepiece/TV = 50/50)	Switchable type (Eyepiece/Tube = 100/0: 0/100)								
		Camera port Mount	C-mount (using optional adapter B*2) Parfocal adjustment with adapter B										Use a laser with TV port.	C-mount receptacle (with green filter switch) (with parfocal adjustment)		
		Protective filter	—										Built-in laser beam filter			
	Tube lens	1X				1X-2X zoom						1X				
	Laser port	Optical features	—										Magnification: 1X λ : 355/532/1064 nm	Magnification: 1X λ : 266/532 nm		
		Mount											YAG laser source (fundamental, second and third harmonic mode) available	YAG laser source (second, fourth harmonic mode) available		
	Microscope head	Coarse and fine movement		Uniaxial coarse and fine movement (Coarse: 3.8 mm/rev. fine 0.1 mm/rev.)												
Movement		50 mm, left and right handle														
Optical system epi-illumination			Epi-illumination for bright-field (Koehler illumination, with aperture diaphragm)													
Illumination unit (optional)			Fiber illumination unit (LED) (No.176-386), 150 W fiber-optic illumination unit (No.176-316) stepless adjustment, light guide length: 1500 mm													
Revolver (required option)			Self-aligning manual revolver nosepiece unit quad / Self-aligning Power revolver nosepiece unit quintuple								Manual revolver nosepiece unit quad / Power revolver nosepiece unit quad	Self-aligning manual revolver nosepiece unit quad / self-aligning power revolver nosepiece unit quintuple				
Suitable objective (required option)	For observation		M Plan Apo M Plan Apo HR M Plan Apo SL G Plan Apo								BD Plan Apo	M Plan Apo M Plan Apo HR M Plan Apo SL G Plan Apo				
	For laser cutting		—								NIR Series NUV Series *Select from wavelengths used by laser source	UV Series				
Loading *3			14.5 kg	13.6 kg	14.1 kg	13.2 kg	14.1 kg (tilting headtype: 13.2 kg)	14.2 kg (tilting headtype: 13.5 kg)	13.9 kg (tilting headtype: 13.1 kg)							
Dimensions			Refer to P.20													
Mass (main unit)			6.1 kg	7.1 kg	6.6 kg	7.5 kg	6.6 kg (tilting headtype: 7.5 kg)	6.4 kg (tilting head type: 7.2 kg)	6.7 kg (tilting head type: 7.5 kg)							

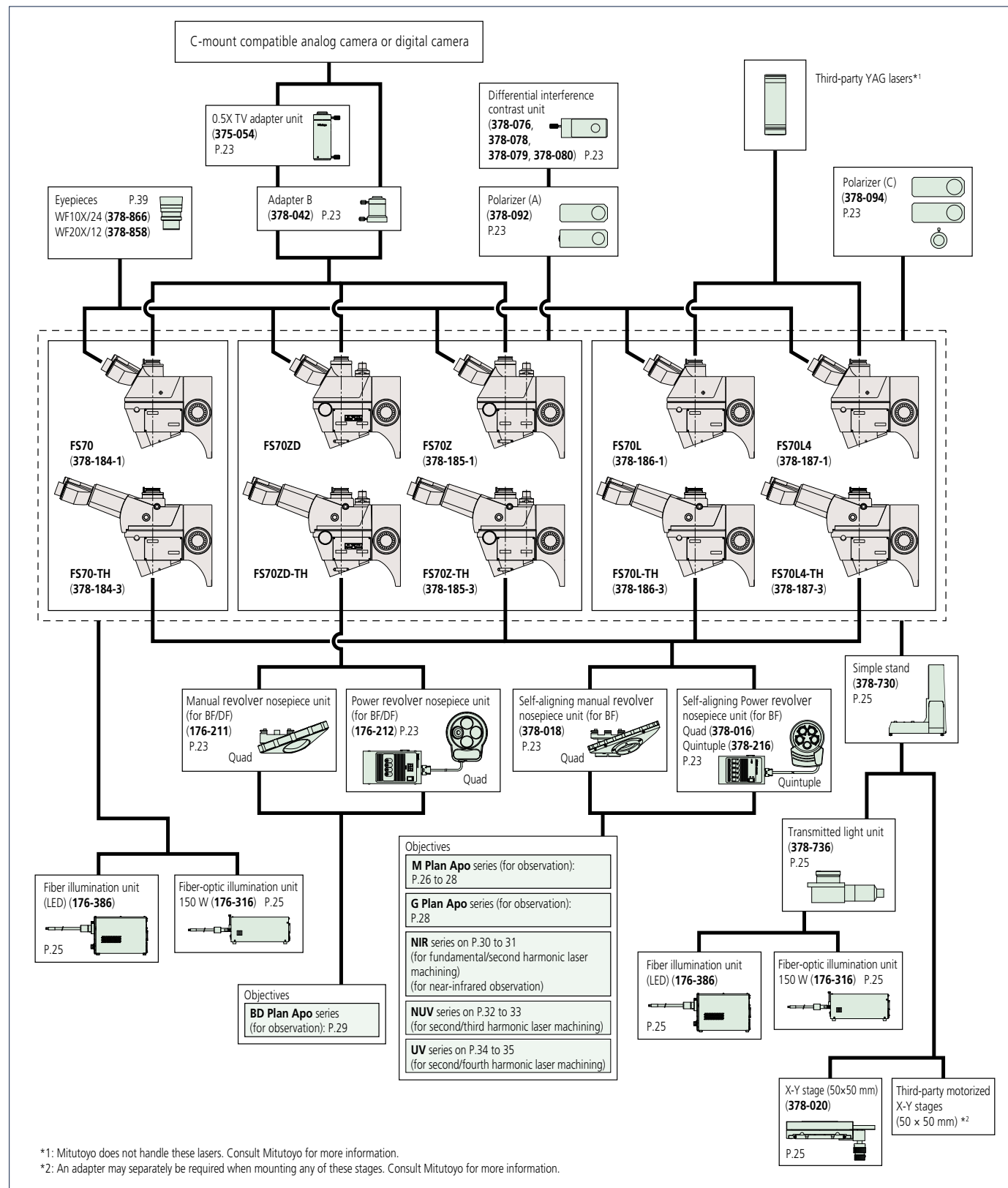
\*1: It is a switchable type when using FS70ZD-TH (Tilting head type). \*2: Installation is optional. \*3: Loading on optical tube excluding weight of revolvers, objective lenses and eyepieces.

Note: When using the objective M Plan Apo 1X, using this lens with a differential interference contrast unit (No.378-092 or 378-094) is recommended.

Note: Observe the following precautions when using FS70L or FS70L4 with YAG laser source attached.

- Be aware of the laser power and energy density limitations of the optical system to avoid damaged.
- Check the mass of the laser source. When mounting on a high-speed device or acceleration/deceleration device, please contact us.

## System diagram



# Optional Accessories for FS70

## Manual revolver



Code No.	378-018	176-211
Observation method	Bright-field	Bright/Dark-field
No. of objective mounts	4 (1 reference hole and 3 holes with centering and parfocal adjustment)	4
View field adjustment	±0.5 mm	—
Parfocal adjustment	±0.5 mm	—
Mass	980 g	1.2 kg

## Polarizer and analyzer

For simplified polarized-light observation. Also suitable for enhancing contrast of low-magnification objectives.



For **FS70Z**  
**378-092**



For **FS70L • FS70L4**  
**378-094**

## DIC unit

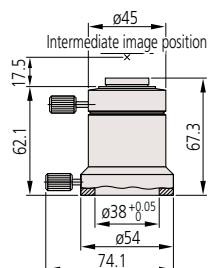
Used for differential interference contrast observation in conjunction with the polarizer.



Code No.	Magnification
<b>378-076</b>	100X, SL80X, SL50X
<b>378-078</b>	50X, SL20X
<b>378-079</b>	20X
<b>378-080</b>	10X, 5X

## Adapter B

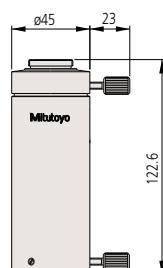
Used for mounting a C-mount camera.



**375-042**  
View field of image: ø11 mm  
Mass: 170 g

## 0.5X TV adapter unit

Allows observation over a wide field of view on the monitor (2X wide) due to the 0.5X relay optics. It is used in conjunction with the optional adapter B. A C-mount is included.



**375-054**  
View field of image: ø11 mm  
Mass: 300 g

## Power revolver



**378-016**



Console box

Code No.	378-216	378-016	176-212
Observation method	Bright-field		Bright/Dark-field
No. of objective mounts	5 (1 reference hole and 4 holes with centering adjustment)	4 (1 reference hole and 3 holes with centering adjustment)	4
View field adjustment	±0.5 mm		—
Positioning accuracy	2 σ = 3 μm	—	—
Durability (life-time)	1 million repositioning operations	—	—
Drive method	DC motor		
Power supply	AC100 V - 240 V, 10 W	AC100 V - 240 V, 6 W	
Output interface	RS-232C*1 for external PC control		
Cable length	2.9 m*2 (connection of power revolver and console box)		
Dimensions (WxHxD) and mass	Revolver: 164x65x137 mm, 1.4 kg (378-216: 130x47x186 mm, 1.7 kg) Console box: 108x72x193 mm, 810 g (378-216: 108x63x176 mm, 810 g)		

\*1: Optional RS-232C Cable: **12AAA807**

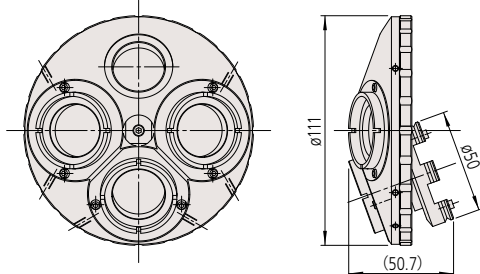
\*2: The length of cable connecting the power revolver and console box is a safe maximum and therefore Mitutoyo does not guarantee error-free operation if a cable extension is used to increase total cable length.



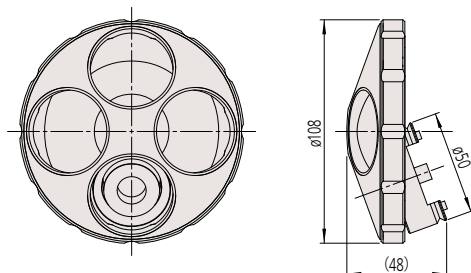
# Dimensions of Optional Accessories for FS70

## Manual revolver

378-018

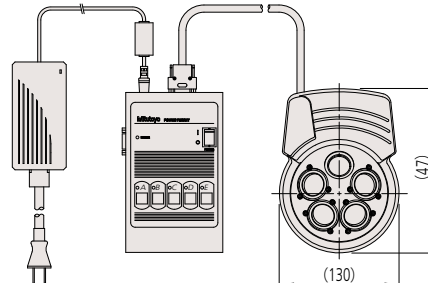


176-211

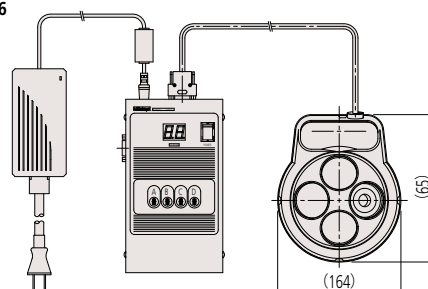


## Power revolver

378-216



176-212/378-016



## Optional objective adapter: 378-026-1

This objective adapter allows mounting the bright-field objective on the bright/dark-field revolver (176-211 and 176-210) while maintaining the focus position (parfocal).

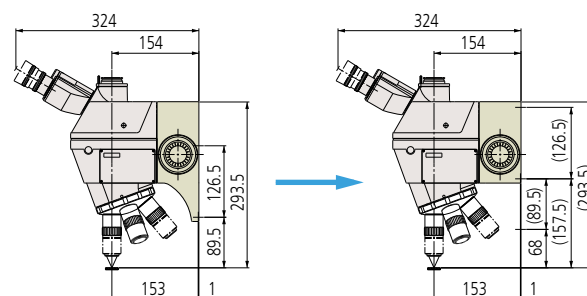
Code No.	378-026-1
Applicable models	Microscopes mounted with the bright/dark-field manual revolver or power revolver (WIDE VMU-BDV/H, MF-U, HyperMF-U)
Applicable objective lens	M Plan Apo, M Plan Apo SL, G Plan Apo, M Plan Apo NIR, M Plan Apo NUV, M Plan UV

## Focus point adjust shim set

Code No.	Use	Details
378-089	For bright-field revolver	The focus point adjust shim set includes 50 $\mu$ m, 30 $\mu$ m and 20 $\mu$ m thickness SUS rings
378-090	For bright/dark-field revolver	

## Short focus unit type

Manual Focus Unit S can be mounted on the main unit 68mm higher than the standard focus unit without changing the eye-point position. The order numbers in the following table represent the FS70-series main units on which this focus unit has previously been mounted.

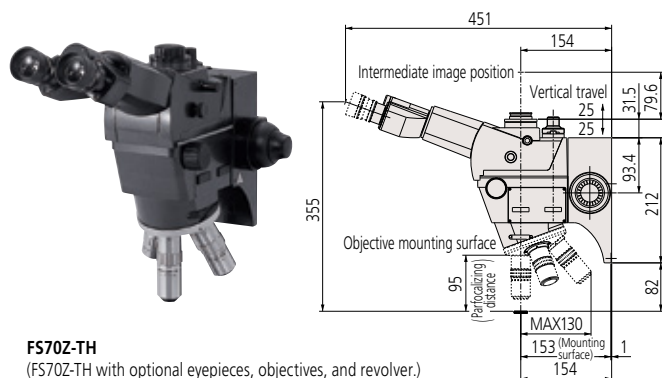


Standard focusing unit mounting dimensions

Manual focusing unit S mounting dimensions

## Tilting head type

Mitutoyo's FS70-series lineup adopts a tilting head specification that allows the user to adjust the head to an appropriate eye point according to personal physical attributes when looking through the microscope eyepiece.



FS70Z-TH

(FS70Z-TH with optional eyepieces, objectives, and revolver.)

Model	FS70-S	FS70Z-S	FS70L-S	FS70L4-S
Code No.	378-184-2	378-185-2	378-186-2	378-187-2
Travel range	50 mm			
Coarse/fine feed	Coarse feed: 3.8 mm/rev., Fine feed: 0.1 mm/rev.			
Loading capacity of camera mount*	14.5 kg	14.1 kg	14.2 kg	13.9 kg
Mass	6.1 kg	6.6 kg	6.4 kg	6.7 kg

\*Mass of revolver, objective, and eyepiece are excluded.

Note: If the tilting head type with a short focus unit is required, please contact your local Mitutoyo sales office.

# Optional Accessories for Microscopes

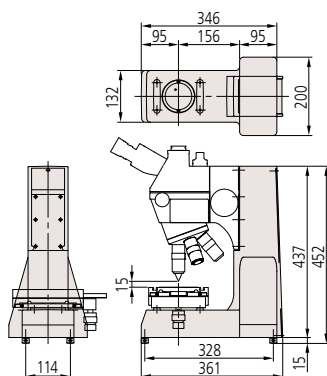
## Stand

For mounting the VMU, WIDE VMU, or FS70 microscope unit. Can be combined with an XY stage, stage illumination unit and fiber-optic illuminator to work as a compact microscope for surface observation.

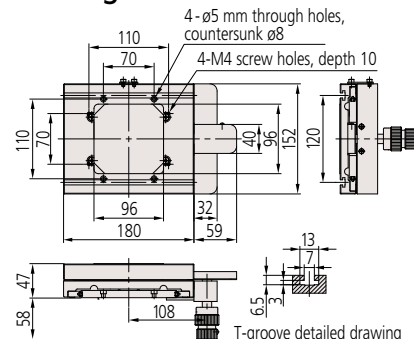


Code No.	<b>378-730</b>
Mass	6.7 kg

Stand with XY stage and stage illumination unit mounted on FS70Z with optional objectives and eyepieces



## XY stage

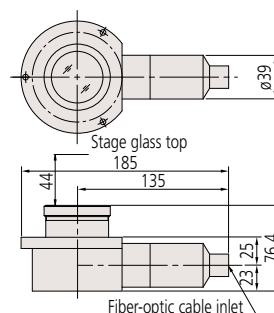


Code No.	<b>378-020</b>
Travel range	50x50 mm
Handle feed	34 mm/rev.
Mass	3.3 kg

Note: Each wheel functions as a single-axis drive.

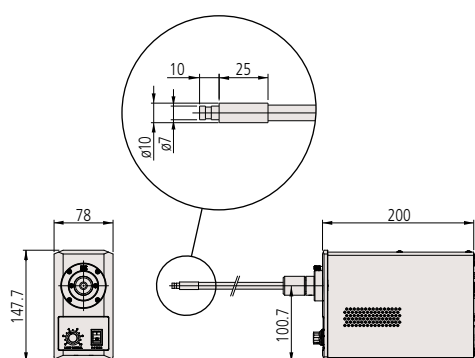
## Stage illumination unit

Attaches to the stand to provide contour illumination in conjunction with a fiber-optic illuminator (100 W or 150 W).



Code No.	<b>378-736</b>
Mass	0.8 kg

## Fiber-optic illuminator (LED)

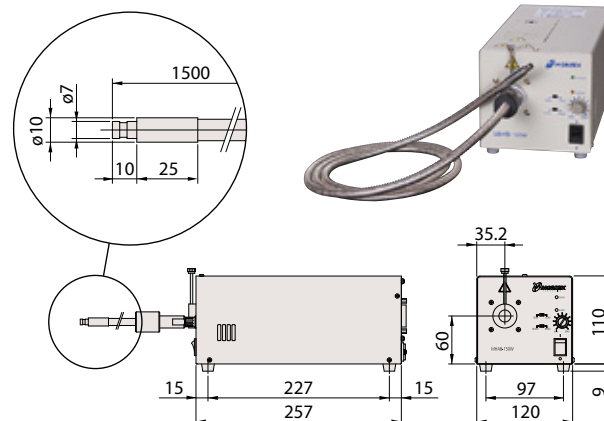


Code No.	<b>176-386</b>
Light source	White, 30,000 h service life*1, 6,500K (typ.)*2
Rated input	AC 100 V - AC 240 V $\pm 10\%$ , 50/60 Hz
Rated power consumption	20 W
Light guide	Fiber-optic cable (1.5 m length, 5 mm dia.)
Brightness	Adjustable by volume

\*1: The LED service life may vary depending on the usage environment. This value is not a guarantee of the service life.

\*2: Color temperature (given as reference)

## Fiber-optic illuminator (150 W)



Code No.		176-316
Light source	Long-life type	15 V/150 W parabolic-type halogen bulb ( <b>12BAJ076</b> ), 500h service life
	High-brightness type	15 V/150 W parabolic-type halogen bulb ( <b>12BAJ075</b> ), 50h service life
Light guide		Fiber-optic cable (1.5 m length, 5 mm dia.)
Brightness		Adjustable by rotary control

## Objectives for bright-field observation (long working distance)

# M Plan Apo / M Plan Apo HR

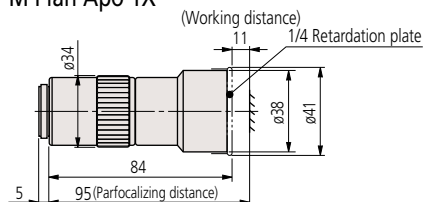
VMU WIDE VMU FS70 MF-U Hyper MF-U

- Features**
- > Bright-field observation
  - > Wavelength compensation range 436 nm to 656 nm (Designed to fundamental wavelength 587 nm)
  - > Infinity corrected
  - > Long working distance
  - > Plan-apochromat
  - > High-resolving power type (M Plan Apo HR)

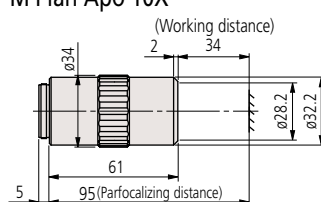


## Dimensions

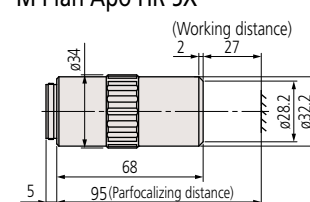
M Plan Apo 1X



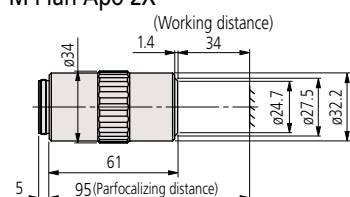
M Plan Apo 10X



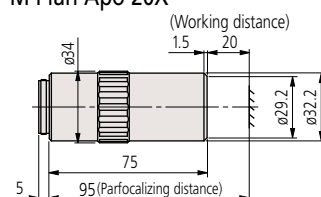
M Plan Apo HR 5X



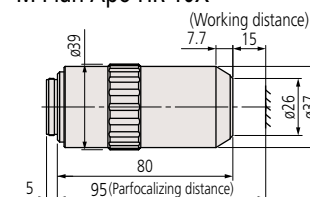
M Plan Apo 2X



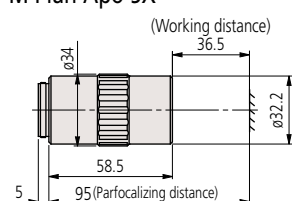
M Plan Apo 20X



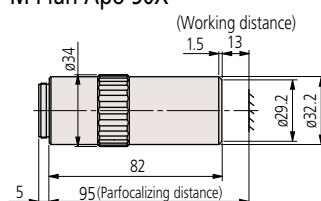
M Plan Apo HR 10X



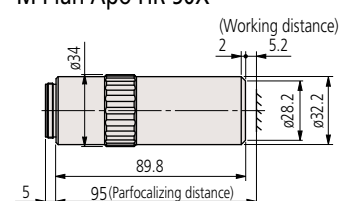
M Plan Apo 5X



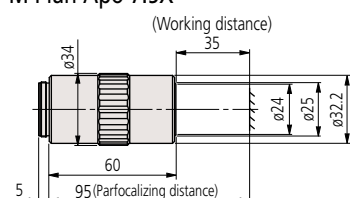
M Plan Apo 50X



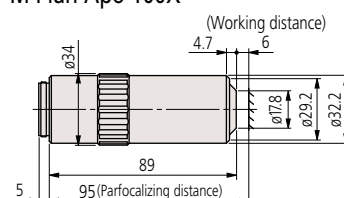
M Plan Apo HR 50X



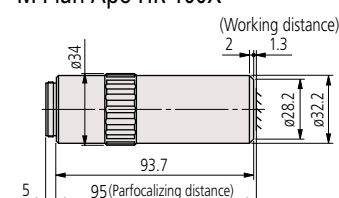
M Plan Apo 7.5X



M Plan Apo 100X



M Plan Apo HR 100X



## Specifications

Model	Code No.	N.A.	W.D. (mm)	f (mm) (λ=550 nm)	R (μm) (λ=550 nm)	±DOF (μm)	Real FOV (mm)		Mass (g)
							ø24 eyepiece	2/3 inch camera	
M Plan Apo									
M Plan Apo 1X *1	378-800-12	0.025	11.0	200	11.0	440	24	6.6x8.8	300
M Plan Apo 2X *2	378-801-12	0.055	34.0	100	5.0	91	12	3.3x4.4	220
M Plan Apo 5X	378-802-12	0.14	36.5	40	2.0	14	4.8	1.32x1.76	262
M Plan Apo 7.5X	378-807-3	0.21	35.0	26.67	1.3	6.2	3.6	0.88x1.17	240
M Plan Apo 10X	378-803-3	0.28	34.0	20	1.0	3.5	2.4	0.66x0.88	240
M Plan Apo 20X	378-804-3	0.42	20.0	10	0.7	1.6	1.2	0.33x0.44	270
M Plan Apo 50X	378-805-3	0.55	13.0	4	0.5	0.9	0.48	0.13x0.18	290
M Plan Apo 100X	378-806-3	0.70	6.0	2	0.4	0.6	0.24	0.07x0.09	320
M Plan Apo HR									
M Plan Apo HR 5X *3	378-787-16	0.21	27.0	40	1.3	6.2	4.8	1.32x1.76	285
M Plan Apo HR 10X *3	378-788-15	0.42	15.0	20	0.7	1.60	2.4	0.66x0.88	455
M Plan Apo HR 50X	378-814-4	0.75	5.2	4	0.4	0.49	0.48	0.13x0.18	400
M Plan Apo HR 100X	378-815-4	0.90	1.3	2	0.3	0.34	0.24	0.07x0.09	410

• Every resolution and single objective's depth of focus in the above table is a value determined on the basis of a reference wavelength ( $\lambda=0.55$   $\mu$ m).

\*1: When observing a workpiece whose optical reflectance is low, an appropriate polarizer should be used with this lens.

\*2: When observing a workpiece whose optical reflectance is low, using this lens with a 1/4 wave plate and polarization unit (No.02ALN370) is recommended.

\*3: These specifications apply to the objectives in isolation and may not apply when a lens is mounted in the revolver of a microscope, depending on the design of that microscope. In the case where the vertical epi-illumination is provided by the user it is important to balance the various optical parameters so that optimum illumination of the target surface is obtained. Contact your local Mitutoyo sales Office for information on how this may be achieved.

## Objectives for bright-field observation (Super-long working distance)

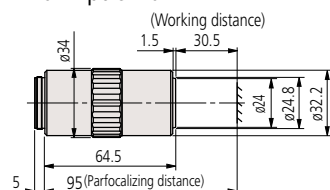
# M Plan Apo SL

VMU WIDE VMU FS70 MF-U Hyper MF-U

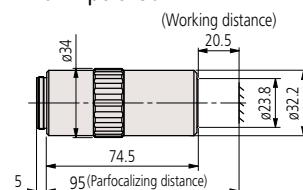
- Features**
- > Bright-field observation
  - > Wavelength compensation range 436 nm to 656 nm (Designed to fundamental wavelength 587 nm)
  - > Infinity corrected
  - > Super long working distance
  - > Plan-apochromat

## Dimensions

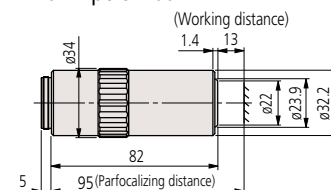
M Plan Apo SL20X



M Plan Apo SL50X



M Plan Apo SL100X



## Specifications

Model	Code No.	N.A.	W.D. (mm)	f (mm) (λ=550 nm)	R (μm) (λ=550 nm)	±DOF (μm)	Real FOV (mm)		Mass (g)
							ø24 eyepiece	2/3 inch camera	
<b>M Plan Apo SL</b>									
M Plan Apo SL20X	378-810-3	0.28	30.5	10	1.0	3.5	1.2	0.33×0.44	240
M Plan Apo SL50X	378-811-15	0.42	20.5	4	0.7	1.6	0.48	0.13×0.18	280
M Plan Apo SL100X	378-813-3	0.55	13.0	2	0.5	0.9	0.24	0.07×0.09	290

• Every resolution and single objective's depth of focus in the above table is a value determined on the basis of a reference wavelength (λ=0.55 μm).

## Objectives for bright-field observation (with cover-glass thickness compensation)

# G Plan Apo

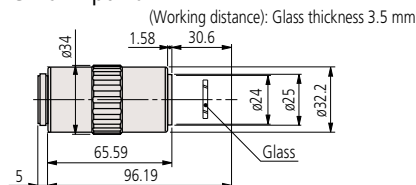
VMU WIDE VMU FS70 MF-U Hyper MF-U

- Features**
- > Bright-field observation
  - > Wavelength compensation range 436 nm to 656 nm (Design to fundamental wavelength 587 nm)
  - > Infinity corrected
  - > Long working distance
  - > Plan-apochromat
  - > Design enables observation through a 3.5 mm cover glass (material: BK7).

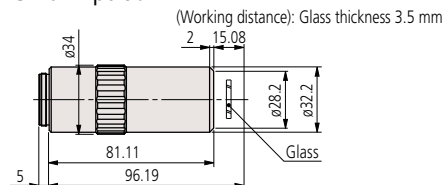
Note: Mitutoyo is ready to design and manufacture a specific sheet of glass according to a specified glass thickness, material or refractive index, please contact your local Mitutoyo sales office.

## Dimensions

G Plan Apo 20X



G Plan Apo 50X



## Specifications

Model	Code No.	N.A.	W.D. (mm)	f (mm) (λ=550 nm)	R (μm) (λ=550 nm)	±DOF (μm)	Real FOV (mm)		Mass (g)
							ø24 eyepiece	2/3 inch camera	
<b>G Plan Apo</b>									
G Plan Apo 20X (t3.5)	378-847	0.28	29.42	10	1.0	3.5	1.2	0.33×0.44	270
G Plan Apo 50X (t3.5)	378-848-3	0.50	13.89	4	0.6	1.1	0.48	0.13×0.18	320

• Every resolution and single objective's depth of focus in the above table is a value determined on the basis of a reference wavelength (λ=0.55 μm).



# Objectives for bright/dark-field observation (long working distance)

## BD Plan Apo

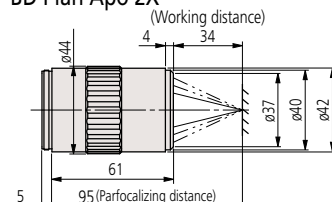
WIDE VMU FS70 MF-U Hyper MF-U

- Features**
- > Bright/dark-field observation
  - > Wavelength compensation range 436 nm to 656 nm  
(Designed to fundamental wavelength 587 nm)
  - > Infinity corrected
  - > Long working distance
  - > Plan-apochromat

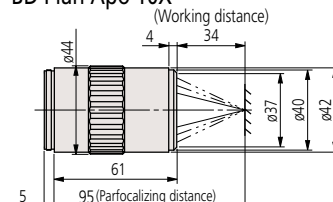


## Dimensions

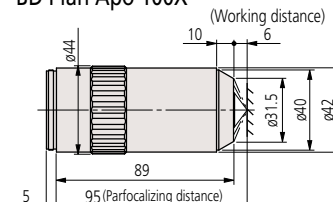
BD Plan Apo 2X



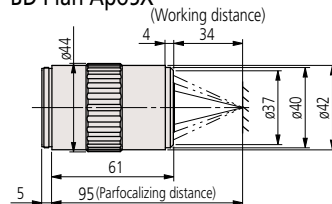
BD Plan Apo 10X



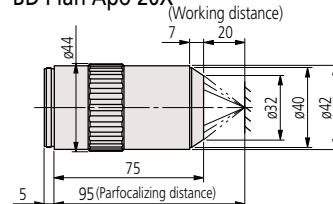
BD Plan Apo 100X



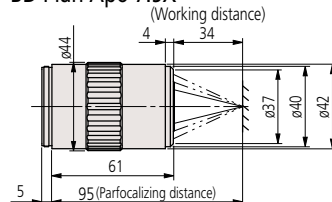
BD Plan Apo 5X



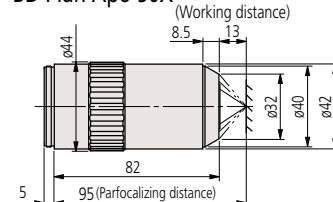
BD Plan Apo 20X



BD Plan Apo 7.5X



BD Plan Apo 50X



## Specifications

Model	Code No.	N.A.	W.D. (mm)	f (mm) (λ=550 nm)	R (μm) (λ=550 nm)	±DOF (μm)	Real FOV (mm)		Mass (g)
							ø24 eyepiece	2/3 inch camera	
BD Plan Apo									
BD Plan Apo 2X*	378-831-13	0.055	34.0	100	5.0	91	12	3.3x4.4	340
BD Plan Apo 5X	378-832-12	0.14	34.0	40	2.0	14	4.8	1.32x1.76	382
BD Plan Apo 7.5X	378-830-7	0.21	34.0	26.67	1.3	6.2	3.6	0.88x1.17	350
BD Plan Apo 10X	378-833-7	0.28	34.0	20	1.0	3.5	2.4	0.66x0.88	350
BD Plan Apo 20X	378-834-7	0.42	20.0	10	0.7	1.6	1.2	0.33x0.44	400
BD Plan Apo 50X	378-835-7	0.55	13.0	4	0.5	0.9	0.48	0.13x0.18	440
BD Plan Apo 100X	378-836-7	0.70	6.0	2	0.4	0.6	0.24	0.07x0.09	460

\* Every resolution and single objective's depth of focus in the above table is a value determined on the basis of a reference wavelength (λ=0.55 μm).

\* It is recommended to be used together with the 1/4 wavelength plate B (02ALN380) and appropriate polarizer for the microscope used (Working distance will be shortened 4 mm).

## Near-infrared radiation range objectives for bright-field observation

# M Plan Apo NIR / M Plan Apo NIR HR / M Plan Apo NIR B

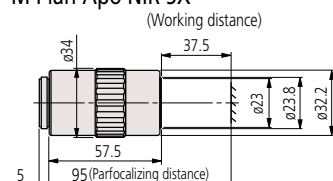
VMU WIDE VMU FS70

- Features**
- > Bright-field observation/near-infrared observation/laser machining
  - > Wavelength compensation range 480 nm to 1800 nm (M Plan Apo NIR B: 420 nm to 1064 nm)
  - > Infinity corrected
  - > Long working distance
  - > Plan-apochromat
  - > High-resolving power type (M Plan Apo NIR HR)
  - > Ultra-long working distance and High spectral transmission factor (M Plan Apo NIR B)

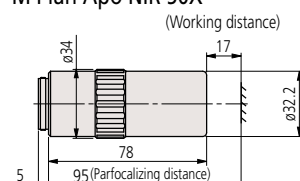


## Dimensions

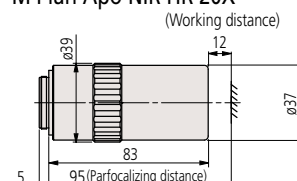
M Plan Apo NIR 5X



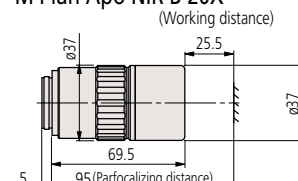
M Plan Apo NIR 50X



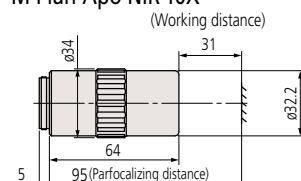
M Plan Apo NIR HR 20X



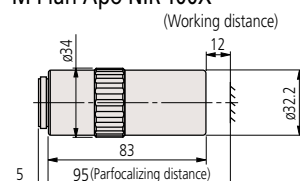
M Plan Apo NIR B 20X



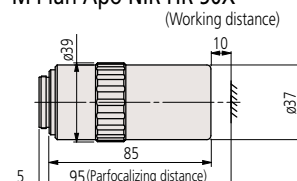
M Plan Apo NIR 10X



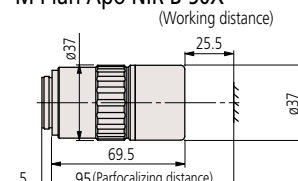
M Plan Apo NIR 100X



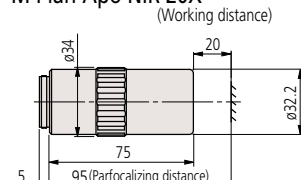
M Plan Apo NIR HR 50X



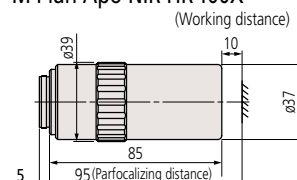
M Plan Apo NIR B 50X



M Plan Apo NIR 20X



M Plan Apo NIR HR 100X



## Specifications

Model	Code No.	N.A.	W.D. (mm)	f (mm) (λ= 550 nm)	R (μm) (λ= 550 nm)	±DOF (μm)	Real FOV (mm)		Mass (g)
							ø24 eyepiece	2/3 inch camera	
M Plan Apo NIR									
M Plan Apo NIR 5X	378-822-5	0.14	37.5	40	2.0	14.0	4.8	1.32×1.76	220
M Plan Apo NIR 10X	378-823-15	0.26	31.0	20	1.1	4.1	2.4	0.66×0.88	250
M Plan Apo NIR 20X	378-824-16	0.40	20.0	10	0.7	1.7	1.2	0.33×0.44	300
M Plan Apo NIR 50X	378-825-17	0.42	17.0	4	0.7	1.6	0.48	0.13×0.18	350
M Plan Apo NIR 100X	378-826-15	0.50	12.0	2	0.6	1.1	0.24	0.07×0.09	335
M Plan Apo NIR HR									
M Plan Apo NIR HR 20X	378-854	0.60	12.0	10	0.46	0.8	1.2	0.33×0.44	470
M Plan Apo NIR HR 50X	378-863-5	0.65	10.0	4	0.4	0.7	0.48	0.13×0.18	450
M Plan Apo NIR HR 100X	378-864-15	0.70	10.0	2	0.4	0.6	0.24	0.07×0.09	490
M Plan Apo NIR B									
M Plan Apo NIR B 20X	378-867-5	0.40	25.5	10	0.7	1.7	1.2	0.33×0.44	350
M Plan Apo NIR B 50X	378-868-5	0.42	25.5	4	0.7	1.6	0.48	0.13×0.18	375

• Every resolution and single objective's depth of focus in the above table is a value determined on the basis of a reference wavelength (λ=0.55 μm).

Note: If the wavelength used is 1100 nm or longer, the focal point may deviate slightly from that in visible radiation.

Near-infrared radiation range objectives for bright-field observation (with cover-glass thickness compensation)

# LCD Plan Apo NIR / LCD Plan Apo NIR HR

VMU WIDE VMU FS70

- Features**
- > Bright-field observation/near-infrared observation/laser machining
  - > Wavelength compensation range 480 nm to 1800 nm
  - > Infinity corrected
  - > Long working distance
  - > Plan-apochromat
  - > Design enables observation through a 3.5 mm or 1.1 mm cover glass (material: BK7).

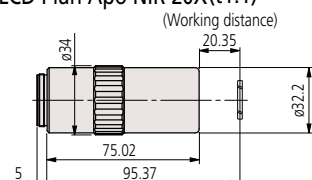
Note: Mitutoyo is ready to design and manufacture a specific sheet of glass according to a specified glass thickness, material or refractive index, please contact your local Mitutoyo sales office.

- > High-resolving power type (LCD Plan Apo NIR HR)

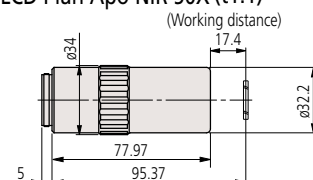


## Dimensions

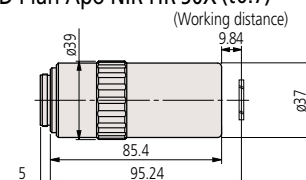
LCD Plan Apo NIR 20X (t1.1)



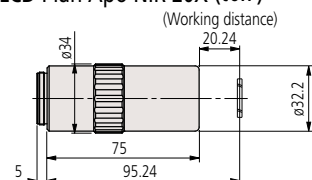
LCD Plan Apo NIR 50X (t1.1)



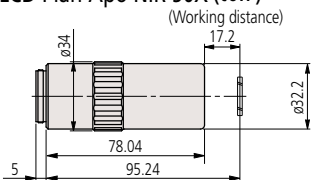
LCD Plan Apo NIR HR 50X (t0.7)



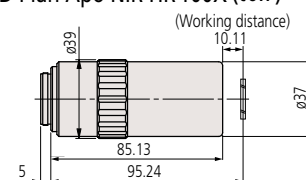
LCD Plan Apo NIR 20X (t0.7)



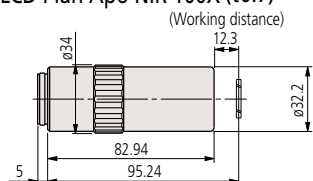
LCD Plan Apo NIR 50X (t0.7)



LCD Plan Apo NIR HR 100X (t0.7)



LCD Plan Apo NIR 100X (t0.7)



## Specifications

Model	Code No.	N.A.	W.D. (mm)	f (mm) (λ=550 nm)	R (μm) (λ=550 nm)	±DOF (μm)	Real FOV (mm)		Mass (g)
							ø24 eyepiece	2/3 inch camera	
LCD Plan Apo NIR									
LCD Plan Apo NIR 20X (t1.1)	378-827-16	0.40	19.98	10	0.7	1.7	1.2	0.33×0.44	305
LCD Plan Apo NIR 20X (t0.7)	378-821-16	0.40	20.00	10	0.7	1.7	1.2	0.33×0.44	305
LCD Plan Apo NIR 50X (t1.1)	378-828-16	0.42	17.13	4	0.7	1.6	0.48	0.13×0.18	320
LCD Plan Apo NIR 50X (t0.7)	378-829-16	0.42	17.26	4	0.7	1.6	0.48	0.13×0.18	320
LCD Plan Apo NIR 100X (t0.7)	378-754-15	0.50	12.06	2	0.6	1.1	0.24	0.07×0.09	335
LCD Plan Apo NIR HR									
LCD Plan Apo NIR HR 50X (t0.7)	378-869-5	0.65	9.6	4	0.4	0.7	0.48	0.13×0.18	450
LCD Plan Apo NIR HR 100X (t0.7)	378-870-15	0.70	9.87	2	0.4	0.7	0.24	0.07×0.09	490

• Every resolution and single objective's depth of focus in the above table is a value determined on the basis of a reference wavelength (λ=0.55 μm).

# Near-ultraviolet radiation range objectives for bright-field observation

# M Plan Apo NUV / M Plan Apo NUV HR

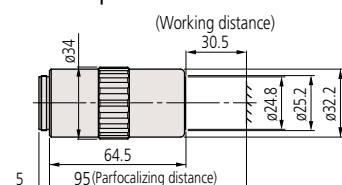
VMU FS70

- Features**
- > Bright-field observation/near-ultraviolet observation/laser machining
  - > Wavelength compensation range 355 nm to 620 nm
  - > Infinity corrected
  - > Long working distance
  - > Plan-apochromat
  - > High-resolving power type (M Plan Apo NUV HR)

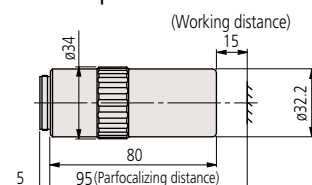


## Dimensions

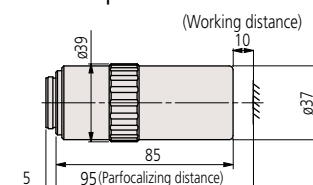
M Plan Apo NUV 10X



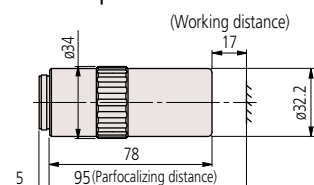
M Plan Apo NUV 50X



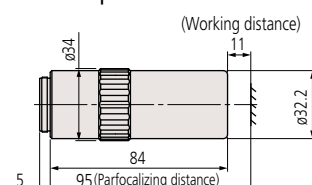
M Plan Apo NUV HR 50X



M Plan Apo NUV 20X



M Plan Apo NUV 100X



## Specifications

Model	Code No.	N.A.	W.D. (mm)	f (mm) (λ=550 nm)	R (μm) (λ=550 nm)	±DOF (μm)	Real FOV (mm)		Mass (g)
							ø24 eyepiece	2/3 inch camera	
M Plan Apo NUV									
M Plan Apo NUV 10X	378-809-5	0.28	30.5	20	1	3.5	2.4	0.66x0.88	255
M Plan Apo NUV 20X	378-817-8	0.42	17.0	10	0.7	1.6	1.2	0.33x0.44	340
M Plan Apo NUV 50X	378-818-8	0.44	15.0	4	0.6	1.4	0.48	0.13x0.18	350
M Plan Apo NUV 100X	378-819-15	0.50	11.0	2	0.6	1.1	0.24	0.07x0.09	380
M Plan Apo NUV HR									
M Plan Apo NUV HR 50X	378-888-6	0.65	10.0	4	0.42	0.65	0.48	0.13x0.18	500

• Every resolution and single objective's depth of focus in the above table is a value determined on the basis of a reference wavelength (λ=0.55 μm).

Near-ultraviolet radiation range objectives for bright-field observation (with cover-glass thickness compensation)

# LCD Plan Apo NUV / LCD Plan Apo NUV HR

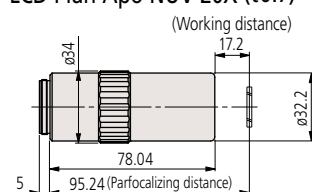
VMU FS70

- Features**
- > Bright-field observation/near-ultraviolet observation/laser machining
  - > Wavelength compensation range 355 nm to 620 nm
  - > Infinity corrected
  - > Long working distance
  - > Plan-apochromat
  - > Design enables observation through a 3.5 mm cover glass (material: BK7)
- Note: Mitutoyo is ready to design and manufacture a specific sheet of glass according to a specified glass thickness, material or refractive index, please contact your local Mitutoyo sales office.
- > High-resolving power type (LCD Plan Apo NUV HR)

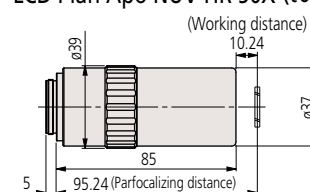


## Dimensions

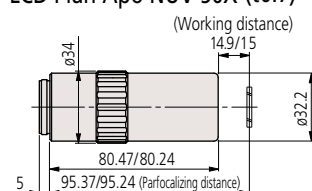
LCD Plan Apo NUV 20X (t0.7)



LCD Plan Apo NUV HR 50X (t0.7)



LCD Plan Apo NUV 50X (t0.7)



## Specifications

Model	Code No.	N.A.	W.D. (mm)	f (mm) (λ=550 nm)	R (μm) (λ=550 nm)	±DOF (μm)	Real FOV (mm)		Mass (g)
							ø24 eyepiece	2/3 inch camera	
LCD Plan Apo NUV									
LCD Plan Apo NUV 20X (t0.7)	378-890-8	0.42	16.96	10	0.7	1.6	1.2	0.33x0.44	340
LCD Plan Apo NUV 50X (t0.7)	378-820-8	0.44	14.76	4	0.6	1.4	0.48	0.13x0.18	350
LCD Plan Apo NUV HR									
LCD Plan Apo NUV HR 50X (t0.7)	378-891-6	0.65	9.76	4	0.4	0.7	0.48	0.13x0.18	500

• Every resolution and single objective's depth of focus in the above table is a value determined on the basis of a reference wavelength (λ=0.55 μm).



# Ultraviolet radiation range objectives for bright-field observation

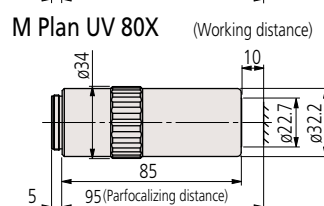
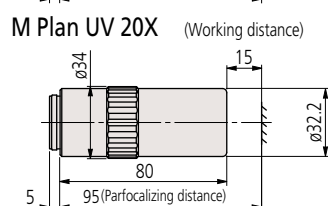
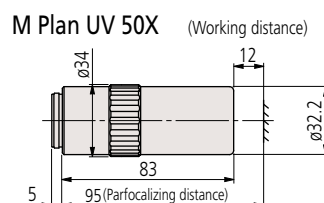
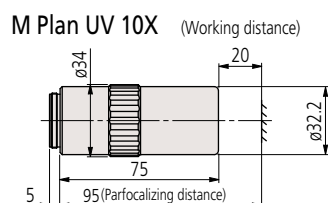
## M Plan UV

VMU FS70

- Features**
- > Bright-field observation/ultraviolet observation/laser machining
  - > Wavelength compensation 266 nm and 550 nm
  - > Infinity corrected
  - > Long working distance
  - > Plan



## Dimensions



## Specifications

Model	Code No.	N.A.	W.D. (mm)	f (mm)		R (μm) (λ=550 nm)	±DOF (μm)	Real FOV (mm)		Mass (g)
				f <sub>266</sub>	f <sub>550</sub>			ø24 eyepiece	2/3 inch camera	
<b>M Plan UV</b>										
<b>M Plan UV 10X</b>	<b>378-844-15</b>	0.25	20.0	20	20.3	1.1	4.4	2.4	0.66×0.88	310
<b>M Plan UV 20X</b>	<b>378-837-8</b>	0.37	15.0	10	10.4	0.7	2.0	1.2	0.33×0.44	370
<b>M Plan UV 50X</b>	<b>378-838-8</b>	0.41	12.0	4	4.2	0.7	1.6	0.48	0.13×0.18	400
<b>M Plan UV 80X</b>	<b>378-839-5</b>	0.55	10.0	2.5	2.9	0.5	0.9	0.3	0.08×0.11	380

- When projecting a mask image on a specimen by using a YAG laser system mounted on a Mitutoyo microscope unit, the mask image will be scaled by the factor f/200 times (f=200 mm, Mitutoyo tube lens). Since the focal length (f) in ultraviolet radiation (λ=266 nm) is slightly smaller than that in visible radiation (λ=550 nm) as above, the working area in ultraviolet radiation also becomes slightly smaller than the mask image in visible radiation.
- Every resolution and single objective's depth of focus in the above table is a value determined on the basis of a reference wavelength (λ=0.55 μm).

## Ultraviolet radiation range objectives for bright-field observation (with cover-glass thickness compensation)

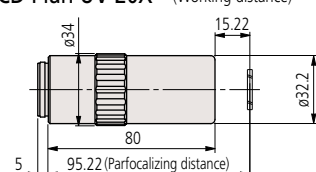
# LCD Plan UV

VMU FS70

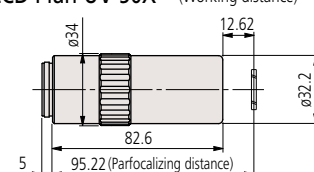
- Features**
- > Bright-field observation/ultraviolet observation/Laser machining
  - > Wavelength compensation 266 nm and 550 nm
  - > Infinity corrected
  - > Long working distance
  - > Plan
  - > Design enables observation through a 3.5 mm cover glass (material: sio2)
- Note: Mitutoyo is ready to design and manufacture a specific sheet of glass according to a specified glass thickness, material or refractive index, please contact your local Mitutoyo sales office.

## Dimensions

LCD Plan UV 20X (Working distance)



LCD Plan UV 50X (Working distance)



## Specifications

Model	Code No.	N.A.	W.D. (mm)	f (mm)		R (μm) (λ=550 nm)	±DOF (μm)	Real FOV (mm)		Mass (g)
				f <sub>266</sub>	f <sub>550</sub>			ø24 eyepiece	2/3 inch camera	
LCD Plan UV										
LCD Plan UV 20X (t0.7)	378-892-8	0.37	14.98	10	10.4	0.7	2.0	1.2	0.33x0.44	370
LCD Plan UV 50X (t0.7)	378-893-8	0.41	12.38	4	4.2	0.7	1.6	0.48	0.13x0.18	400

• When projecting a mask image on a specimen by using a YAG laser system mounted on a Mitutoyo microscope unit, the mask image will be scaled by the factor  $f/200$  times ( $f=200$  mm, Mitutoyo tube lens). Since the focal length ( $f$ ) in ultraviolet radiation ( $\lambda=266$  nm) is slightly smaller than that in visible radiation ( $\lambda=550$  nm) as above, the working area in ultraviolet radiation also becomes slightly smaller than the mask image in visible radiation.

• Every resolution and single objective's depth of focus in the above table is a value determined on the basis of a reference wavelength ( $\lambda=0.55$  μm).

# Tube lens MT

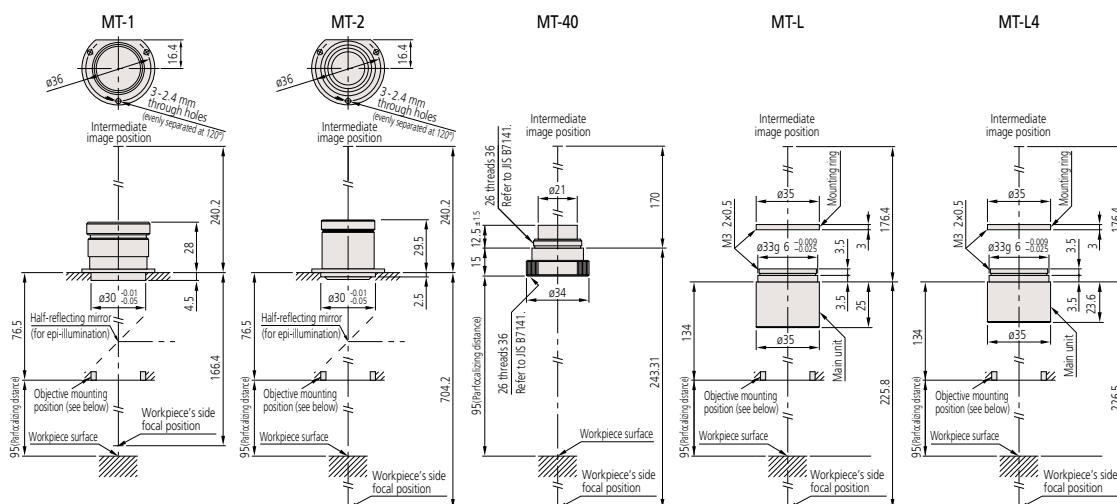
## Aberration correction range

**MT-1, 2, 40:** Visible wavelength range (435.8 – 656.3 nm)

**MT-L:** Near-ultraviolet (355 nm) to near-infrared (1800 nm)

**MT-L4:** Ultraviolet (266 nm) to visible (620 nm)

## Dimensions



## Specifications

Code No.	Focal length (mm)	Magnification (tube lens)	Image field (mm)	Effective lens dia. (mm)	Dimensions (mm)	Mass (g)
<b>970208</b>	200	1X	ø30	ø24.0	ø40×32.5	43
<b>970209</b>	400	2X	ø30	ø18.0	ø40×32.0	42
<b>378-010</b>	200	1X	ø24	ø11.2	ø34×27.5	45
<b>378-008</b>	200	1X	ø24	ø22.0	ø35×32.0	30
<b>378-009</b>	200	1X	ø24	ø23.0	ø35×30.6	30

Note: A distance of 76.5mm in 970208 and 970209 drawings is for an image field of ø30 (without vignetting). For an image field of ø24 or ø11 (the latter is the image field of a 2/3-inch camera), use the formula (1) and (2) below to calculate the distance.

# Reference: Placement of Objective and Tube Lens

VMU and WIDE VMU and FS70 employs an infinity-corrected optical system in which the image is created by an objective lens and an imaging (tube) lens. Mitutoyo's long working-distance objective lenses are designed to cover a field of view of up to ø30 mm (when the tube lens **970208** or **970209** is placed) and up to ø24 mm (when the tube lens **378-008**, **378-009** or **378-010** is placed) at the specified distance from the objective. However, use the following formula to calculate the approximate distance, when a different distance other than that as specified is required in order to insert your own optical system or other optical elements:

$$\ell = (\phi_2 - \phi_1) \cdot f_2 / \phi \quad (1)$$

$$\phi_1 = 2 \cdot f \cdot \text{N.A.} \quad (2)$$

$\phi_1$  : Objective exit pupil diameter (mm)  
 $\phi_2$  : Effective diameter of tube lens (mm)  
 $f_2$  : Focal length of tube lens (mm)  
 $\phi$  : Image field diameter (mm)

Example: What is the distance ( $\ell$ ), when using **M Plan Apo 10X\*** and tube lens\*\* (**970208**) to cover an image field of ø24?

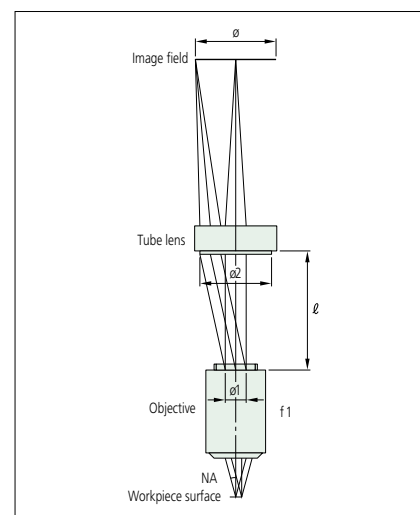
\* $f=20$  mm, N.A.=0.28 (Refer to page 16.) \*\* $\phi_2=24$  mm,  $f_2=200$  mm (Refer to the above chart.)

From formula (2):  $\phi_1 = 2 \times 20 \times 0.28$   
 $= 11.2$  (mm)

From formula (1):  $\ell = (24 - 11.2) \times 200 / 24$   
 $= 106.6$  (mm)

Therefore a distance ( $\ell$ ) up to 106 mm can cover an image field of ø24 without shading.

In other words a distance ( $\ell$ ) smaller than the specification does not affect optical performance.  
 Contact Mitutoyo for detailed information.



# Objectives for measuring microscopes

## ML

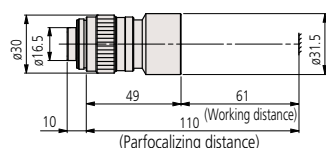
MF Hyper MF

- Features**
- > Finite-correction  
(image-object distance: 280 mm, parfocalizing distance : 110 mm)
  - > Bright-field observation
  - > Long working distance
  - > Telecentric for lenses lower than 10X magnification

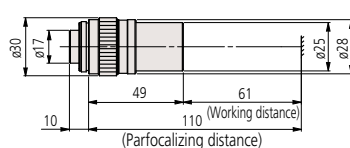


## Dimensions

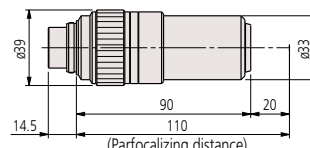
ML 1X



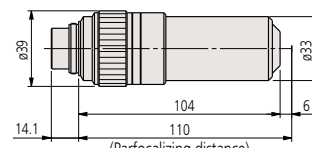
ML 5X



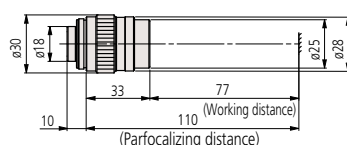
ML 20X



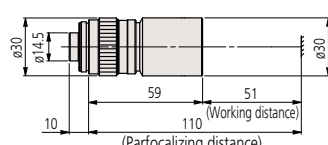
ML 100X



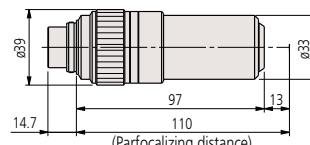
ML 3X



ML 10X



ML 50X



Note: The parfocalizing distance is a nominal value.

## Specifications

Model	Code No.	N.A.	W.D. (mm)	R (μm) (λ= 550 nm)	±DOF (μm)	Real FOV (mm)		Mass (g)
						ø24 eyepiece	1/2 inch camera	
ML 1X	375-036-2	0.03	61.0	9.2	306	24	4.8×6.4	80
ML 3X	375-037-1	0.09	77.0	3.06	34	8	1.6×2.1	55
ML 5X	375-034-1	0.13	61.0	2.12	16.3	4.8	0.96×1.28	60
ML 10X	375-039	0.21	51.0	1.31	6.2	2.4	0.48×0.64	95
ML 20X	375-051	0.42	20.0	0.65	1.6	1.2	0.24×0.32	310
ML 50X	375-052	0.55	13.0	0.5	0.9	0.48	0.10×0.13	350
ML 100X	375-053	0.70	6.0	0.4	0.6	0.24	0.05×0.06	380

• Every resolution and single objective's depth of focus in the above table is a value determined on the basis of a reference wavelength (λ=0.55 μm).

# Objectives for centering microscopes

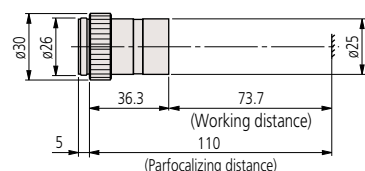
## CF

CF

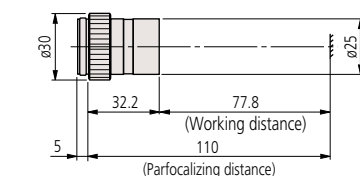
- Features**
- > Finite-correction  
(image-object distance: 280 mm, parfocalizing distance: 110 mm)
  - > Bright-field observation
  - > Long working distance

## Dimensions

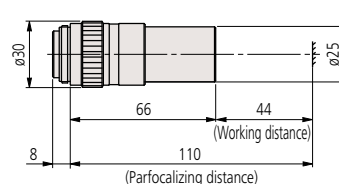
CF 1X



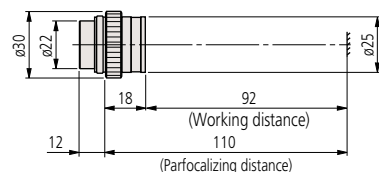
CF 3X



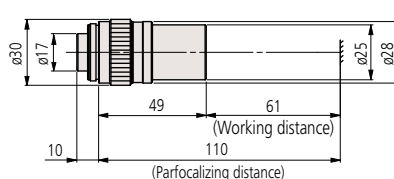
CF 10X



CF 2X



CF 5X



Note: The parfocalizing distance is a nominal value.

## Specifications

Model	Code No.	N.A.	W.D. (mm)	R (μm) (λ=550 nm)	±DOF (μm)	Real FOV (mm)		Mass (g)
						ø24 eyepiece	1/2 inch camera	
CF 1X	375-031	0.03	73.7	9.2	306	24	4.8×6.4	45
CF 2X	375-032	0.06	92.0	4.6	76	12	2.4×3.2	35
CF 3X	375-033	0.07	77.8	3.9	56	8	1.6×2.1	35
CF 5X	375-034-1	0.13	61.0	2.12	16.3	4.8	0.96×1.28	60
CF 10X	375-035	0.18	44.0	1.5	8	2.4	0.48×0.64	100

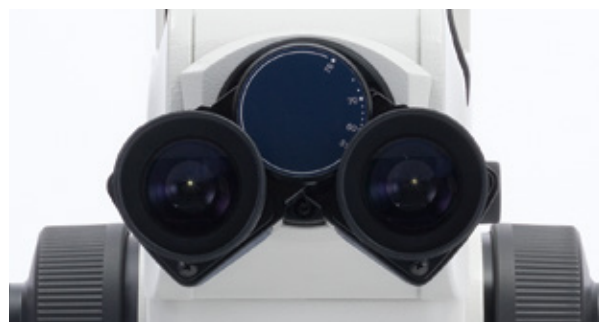
• Every resolution and single objective's depth of focus in the above table is a value determined on the basis of a reference wavelength (λ=0.55 μm).

# Wide field of view eyepieces and reticles

## WF

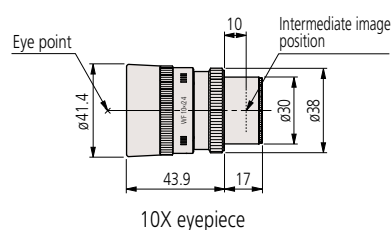
MF MF-U Hyper MF Hyper MF-U FS70

- Features**
- > Eyepiece for wide field of view
  - > Adopt an outside focus type of optical system
  - > Various reticles can be attached according to usage purposes

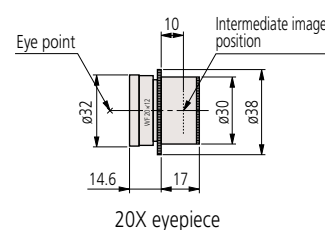


## Dimensions

WF 10X/24



WF 20X/12



## Specifications

Code No. (2pcs.)	Model	Magnification	Field number	Visibility adjustment	Eye point	Reticle	Mass (g)
378-866	Wide field of view eyepiece WF10X/24	10X	24	-10D to +5D	High eye point	Available	150
378-858	Wide field of view eyepiece WF20X/12	20X	12	-8D to +5D	Normal	Available	55

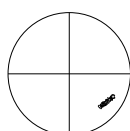
Note: The above lenses are provided as a set of 2.

# Reticles

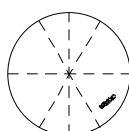
- Features**
- > Simple dimensional measurement is possible by inserting into the eyepiece (intermediate image position): No.378-866, 378-857, and 378-858
  - > Reticle line width 10  $\mu\text{m}$ ...No.516576 only 7  $\mu\text{m}$
  - > Outer diameter  $\varnothing 25$  mm, thickness 1 mm

## Dimensions

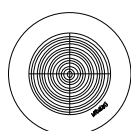
No.516848



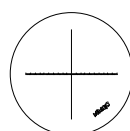
No.516576



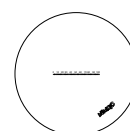
No.516578



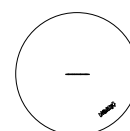
No.516577



No.516849



No.516850



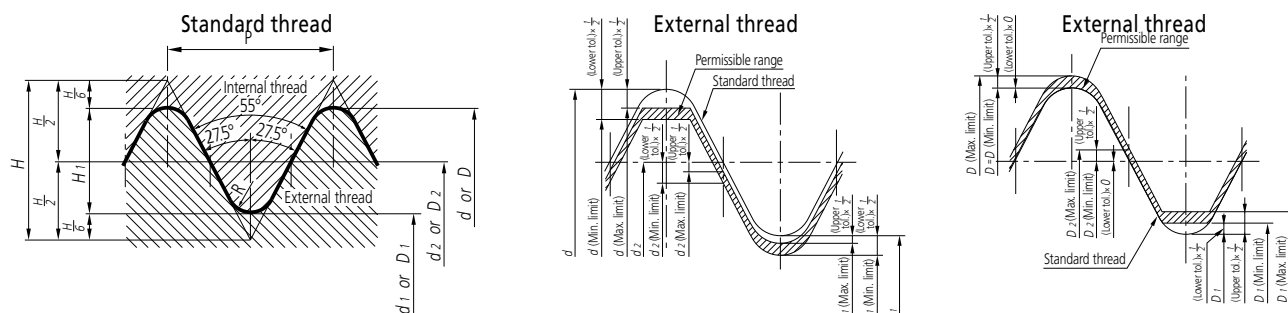
## Specifications

Code No.	516848	516576	516578	516577	516849	516850
Remarks	Solid crosshairs	90° and 60° broken crosshairs	Concentric circles ( $\varnothing 1.2 - 18$ mm) with solid crosshairs	Solid crosshairs with scale graduated 0.1 mm/20 mm	10 mm scale with 0.1 mm graduations	5 mm scale with 0.05 mm graduations



# Reference: Specifications of Objective Threads

1. Scope: These specifications are applied to the threads of Mitutoyo microscope objectives.
2. The thread forms and dimensions are specified as follows conforming to JIS B-7141-1994.



## Bright-field objectives Measuring microscope/centering microscope objectives

### Nominal dimensions

Unit: mm

Nominal thread diameter	Number of threads (per 25.4 mm) n	Pitch P	Thread peak & valley curvature radius R	External thread		
				OD (d)	Pitch diameter (d <sub>2</sub> )	Root diameter (d <sub>1</sub> )
				Root diameter (D)	Pitch diameter (D <sub>2</sub> )	ID (D <sub>1</sub> )
26	36	0.706	0.097	26.000	25.548	25.096

### Permissible limits of size and dimensional tolerance

Unit: mm

Applicable dimensions		External thread			Internal thread	
		OD (d)	Pitch diameter (d <sub>2</sub> )	Root diameter (d <sub>1</sub> )	Root diameter (D)	Pitch diameter (D <sub>2</sub> )
Permissible limits	Max. limit	25.896	25.502	25.050	26.076	25.624
	Min. limit	25.820	25.426	24.974	26.000	25.548
Dimensional tolerance	Upper tolerance	-0.104	-0.046	-0.046	+0.076	+0.076
	Lower tolerance	-0.180	-0.122	-0.122	0	0

## Bright/dark-field objectives

### Nominal dimensions

Unit: mm

Nominal thread diameter	Number of threads (per 25.4 mm) n	Pitch P	Thread peak & valley curvature radius R	External thread		
				OD (d)	Pitch diameter (d <sub>2</sub> )	Root diameter (d <sub>1</sub> )
				Root diameter (D)	Pitch diameter (D <sub>2</sub> )	ID (D <sub>1</sub> )
40	36	0.706	0.097	40.000	39.548	39.096

### Permissible limits of size and dimensional tolerance

Unit: mm

Applicable dimensions		External thread			Internal thread	
		OD (d)	Pitch diameter (d <sub>2</sub> )	Root diameter (d <sub>1</sub> )	Root diameter (D)	Pitch diameter (D <sub>2</sub> )
Permissible limits	Max. limit	39.896	39.502	39.050	40.076	39.624
	Min. limit	39.820	39.426	38.974	40.000	39.548
Dimensional tolerance	Upper tolerance	-0.104	-0.046	-0.046	+0.076	+0.076
	Lower tolerance	-0.180	-0.122	-0.122	0	0

# Reference: Transmission of Mitutoyo Objectives

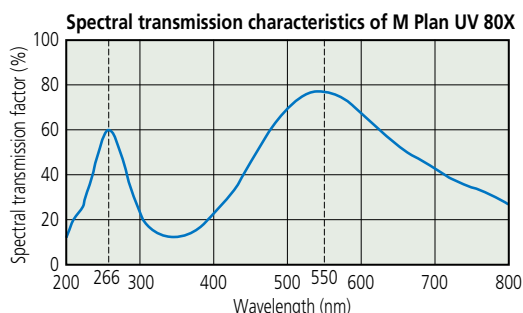
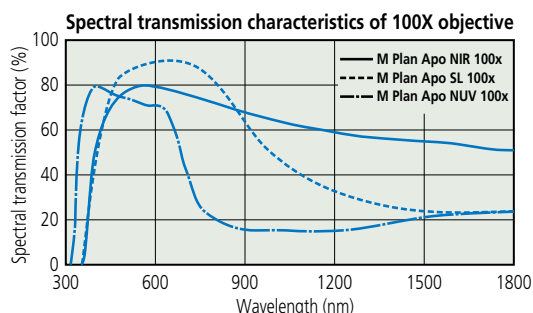
Mitutoyo's long working-distance objectives are grouped by working wavelength range: ultraviolet, near-ultraviolet, visible, and near-infrared. The M Plan UV series (for ultraviolet), M Plan Apo NUV series (for near-ultraviolet), and M Plan Apo NIR series (for near-infrared) are designed especially for YAG laser working applications in cutting thin films. Each series is designed for optimal spectral transmission factor within its respective wavelength range.

**M (BD) Plan Apo** series: Wavelength range 436 nm to 656 nm

**M Plan Apo NIR** series: Wavelength range 480 nm to 1800 nm

**M Plan Apo NUV** series: Wavelength range 355 nm to 620 nm

**M Plan UV** series: Optimized for wavelengths of 266 nm and 550 nm



N.A.: Numerical aperture W.D.: Working distance f: Focal length R: Resolving power DOF: Depth of field FOV: Real field of view

# Commentary: Laser Operating Method and Precautions

Each VMU and FS70 series of Mitutoyo microscope units uses a built-in laser [mainly, Nd-YAG laser fundamental wave (1064 nm), second harmonic (532 nm), third harmonic (355 nm) and fourth harmonic (266 nm)] to allow laser machining. In laser machining with a laser-equipped microscope unit and a microscope objective, high-power laser irradiation is not allowed for the purpose of microfabrication.

IMPORTANT: Review laser safety precautions prior to use.

## Laser input conditions of laser-equipped microscope unit

Determine the upper limit value of laser input under the following conditions. Laser radiation incident on the optical system shall be axial and non-polarized.

### VMU series

Applicable model	VMU-LB			VMU-L4B			
Wavelength used (nm)	1064	532	355	1064	532	355	266
Pulse laser							
Upper input limit (J/cm <sup>2</sup> )	0.099	0.075	0.025	0.11	0.080	0.035	0.015
Pulse width (10 ns)							
Upper limit to CW laser input (kW/cm <sup>2</sup> )	0.22	0.18	0.07	0.2	0.19	0.05	0.05

### FS70 series

Applicable model	FS70L			FS70L4	
Wavelength used (nm)	1064	532	355	532	266
Pulse laser					
Upper input limit (J/cm <sup>2</sup> )	0.090	0.075	0.018	0.075	0.015
Pulse width (10 ns)					
Upper limit to CW laser input (kW/cm <sup>2</sup> )	0.23	0.18	0.06	0.2	0.05

## Upper limit to objective laser input

Determine the upper limit value of laser input under the following conditions if the laser radiation directly enters the objective.

Laser radiation incident on the optical system shall be axial.

### VMU series

Applicable objective	NIR series	NIR series NUV series UV series	NUV series	UV series
Wavelength used (nm)	1064	532	355	266
Pulse laser				
Upper input limit (J/cm <sup>2</sup> )	0.2	0.1	0.05	0.04
Pulse width (10 ns)				
Upper limit to CW laser input (kW/cm <sup>2</sup> )	0.5	0.25	0.16	0.12

Note: If the pulse width of the laser is shortened, reduce the irradiation energy density by the square root of the ratio of the new pulse width to the initial pulse width.

Example: If the pulse width decreases to 1/4 of the initial width, reduce the energy density to approximately 1/2.

Therefore when using a laser with a wavelength of 1064 nm and a pulse width of 2.5 ns, the upper limiting value of input will be 0.1 J/cm<sup>2</sup>.

# Glossary

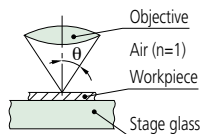
## 1. N.A. (numerical aperture)

N.A. determines resolving power, depth of field, and luminosity of the image. The larger the N.A. the higher is the resolving power and smaller is the depth of field.

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

$n$  is the index of refraction of the medium in which the lens is working.  
 $n=1.0$  for air.

$\theta$  is the half-angle of the maximum cone of light that can enter or exit the lens.



## 2. R (resolving power)

Minimum distance between points or lines that are just distinguishable as separate entities.

Resolving power is determined by N.A. and wavelength  $\lambda$ .

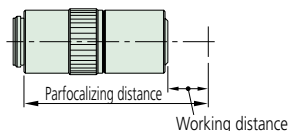
$$R (\mu m) = \frac{\lambda}{2 \cdot N.A.}$$

## 3. W.D. (working distance)

Distance between the surface of the specimen and the front face of the objective when in focus.

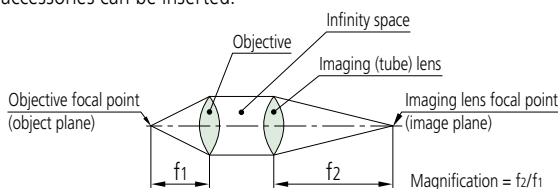
## 4. Parfocalizing distance

Distance between the surface of the specimen and the objective's seating surface when in focus.



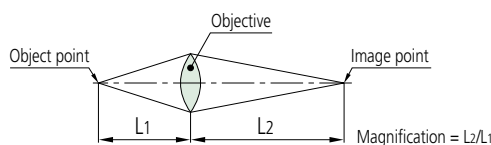
## 5. Infinity-corrected optical system

An optical system in which the image is formed by an objective and a tube lens with an 'Infinity Space' between them, into which optical accessories can be inserted.



## 6. Finite-corrected optical system

An optical system in which the image is formed only by an objective lens.



## 7. F (focal length)

Distance between a principal point and a focal point.  $f^1$  is the focal length of an objective,  $f^2$  is the focal length of a tube lens. Magnification is determined by the ratio of the focal length of the tube lens to that of the objective. (For an infinity-corrected optical system)

$$\text{Magnification of objective} = \frac{\text{Focal length of tube lens}}{\text{Focal length of objective}}$$

$$\text{(E.g.) } 1X = \frac{200 \text{ (mm)}}{200 \text{ (mm)}} \quad \text{(E.g.) } 10X = \frac{200 \text{ (mm)}}{20 \text{ (mm)}}$$

## 8. Field number and FOV (real field of view)

The field number of an eyepiece is determined by the field stop diameter of the eyepiece and it is expressed in mm.

FOV is the area of specimen observable and is determined by the field number of the eyepiece and magnification of the objective.

$$\text{FOV (mm)} = \frac{\text{Field number of eyepiece}}{\text{Magnification of objective}}$$

(E.g. Using an eyepiece of field number 24)

$$\text{FOV for 1X objective} = \frac{24}{1} = \varnothing 24 \text{ (mm)}$$

$$\text{FOV for 10X objective} = \frac{24}{10} = \varnothing 2.4 \text{ (mm)}$$

## Area of specimen observable on TV monitor

$$\text{Area of specimen observable on TV monitor} = \frac{\text{Area of camera image element (VxH)}}{\text{Magnification of objective}}$$

## Indication magnification on TV monitor

$$\text{Indication magnification on TV monitor} = \text{Magnification of objective} \times \frac{\text{Diagonal line length of monitor indication}}{\text{Diagonal line length of camera image element}}$$

Note: Size of camera image element (V x H x Diagonal)

1/3 inch image element: 3.6x4.8x6.0 mm    1/2 inch image element: 4.8x6.4x8.0 mm  
2/3 inch image element: 6.6x8.8x11.0 mm

## 9. DOF (depth of field)

Vertical distance in the specimen, measured from above and below the exact plane of focus, which still yields an acceptable image. The larger the N.A., the smaller the depth of field.

### Eyepiece observation (Berek's)

$$\pm \text{DOF} (\mu m) = \frac{\omega \times 250.000}{N.A. \times M} + \frac{\lambda}{2 \times (N.A.)^2} \quad \lambda = \text{Standard wavelength (550 nm)}$$

$\omega$ : Resolution of human eye (Visual angle: 5 minute)

$M$ : Total magnification (Objective mag. x Eyepiece mag.)

### TV monitor observation

$$\pm \text{DOF} (\mu m) = \frac{\lambda}{2 \times (N.A.)^2} \quad \lambda = \text{Standard wavelength (550 nm)}$$

## 10. Bright-field illumination and dark-field illumination

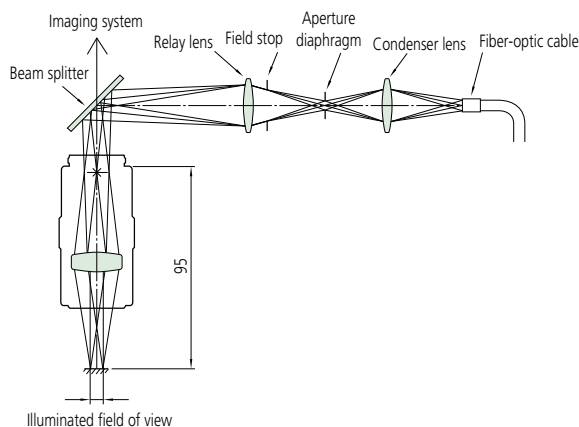
Bright-field illumination directly lights the specimen with a solid cone of rays and is the simplest method available. Dark-field illumination uses a hollow cone of rays formed by an opaque stop at the center of the condenser large enough to prevent direct light from entering the objective. The specimen is placed at the concentration of the light cone, and is seen with light scattered or diffracted by it, therefore scratches and dents on the specimen surface are illuminated while the rest remains dark.

## 11. Apochromatic objective and achromatic objective

An apochromatic objective is corrected for chromatic aberration at the red, green and blue wavelengths. An achromatic objective is corrected for chromatic aberration at the red and blue wavelengths only.

## 12. Köhler illumination

Köhler illumination overcomes the disadvantages of other schemes by causing parallel rays to light the specimen so that, because they will not be in focus, the image of the specimen will not include an image of the light source.



## 13. Telecentric illumination

This illuminating optical system is designed so that principal light passes through the focal point. This system has the advantage of retaining the size of the image center even if it is out of focus (although the circumference of the image is defocused). This illumination system provides an even illumination intensity over the entire field of view.

## 14. Aperture diaphragm

This diaphragm adjusts the amount of light passing through and is related to the brightness and resolving power of an optical system. This diaphragm is especially useful in width dimension measurement of cylindrical objects with contour illumination, and provides the highest degree of correct measurement/observation by suppressing diffraction in an optimal aperture.

## 15. Field stop

This diaphragm is used for blocking out unwanted light and thereby preventing it from degrading the image.

## 16. Plan

Denotes an objective lens that produces a flat (planar) image by correcting the spherical aberration/curvature of the field of an achromatic lens or an apochromatic lens. All Mitutoyo FS series objectives are plan apochromat.

## 17. Vignetting

This unwanted effect is the reduction of an image's brightness or saturation at the periphery compared to the image center. May be caused by external (lens hood) or internal features (dimensions of a multi-element lens).

## 18. Flare

Lens flare is typically seen as several starbursts, rings, or circles in a row across the image or view, caused by unwanted image formation mechanisms, such as internal reflection and scattering of light.

## 19. Double image

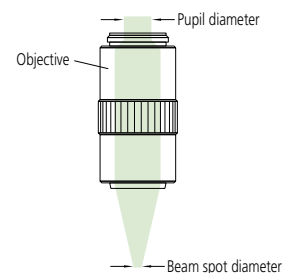
An image degrading a phenomenon in which an image appears as if it is a double image due to redundant light projection and optical interference within the optical system.

## 20. Pupil diameter and spot diameter of an objective

### • Pupil diameter

Denotes the maximum diameter of a parallel light flux along the optical axis that can enter an objective from the rear. The pupil diameter is calculated according to the following expression.

$$\phi \text{ mm} = 2 \times \text{N.A.} \times f_1$$



### • Spot diameter

If a beam of light with a uniformly distributed intensity enters an objective from the rear, the beam is focused to a spot of finite size. This size is known as the spot diameter. The approximate value of a spot diameter is calculated from the following expression.

$$\phi \mu\text{m} = 1.22 \times \frac{\lambda}{\text{N.A.}}$$

However, the above expression cannot be applied if the light source is a laser beam of which the intensity forms a Gaussian distribution on the cross section. The diameter of a laser beam is generally indicated by  $1/e^2$  of the peak value, i.e. 13.5% of the peak value. The spot diameter of a laser beam is calculated from the following expression.

$$\phi \mu\text{m} = \frac{4\lambda \times f}{\pi \times D}$$

(where  $\lambda$  is in  $\mu\text{m}$ ;  $f$  and  $D$  are in mm)



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