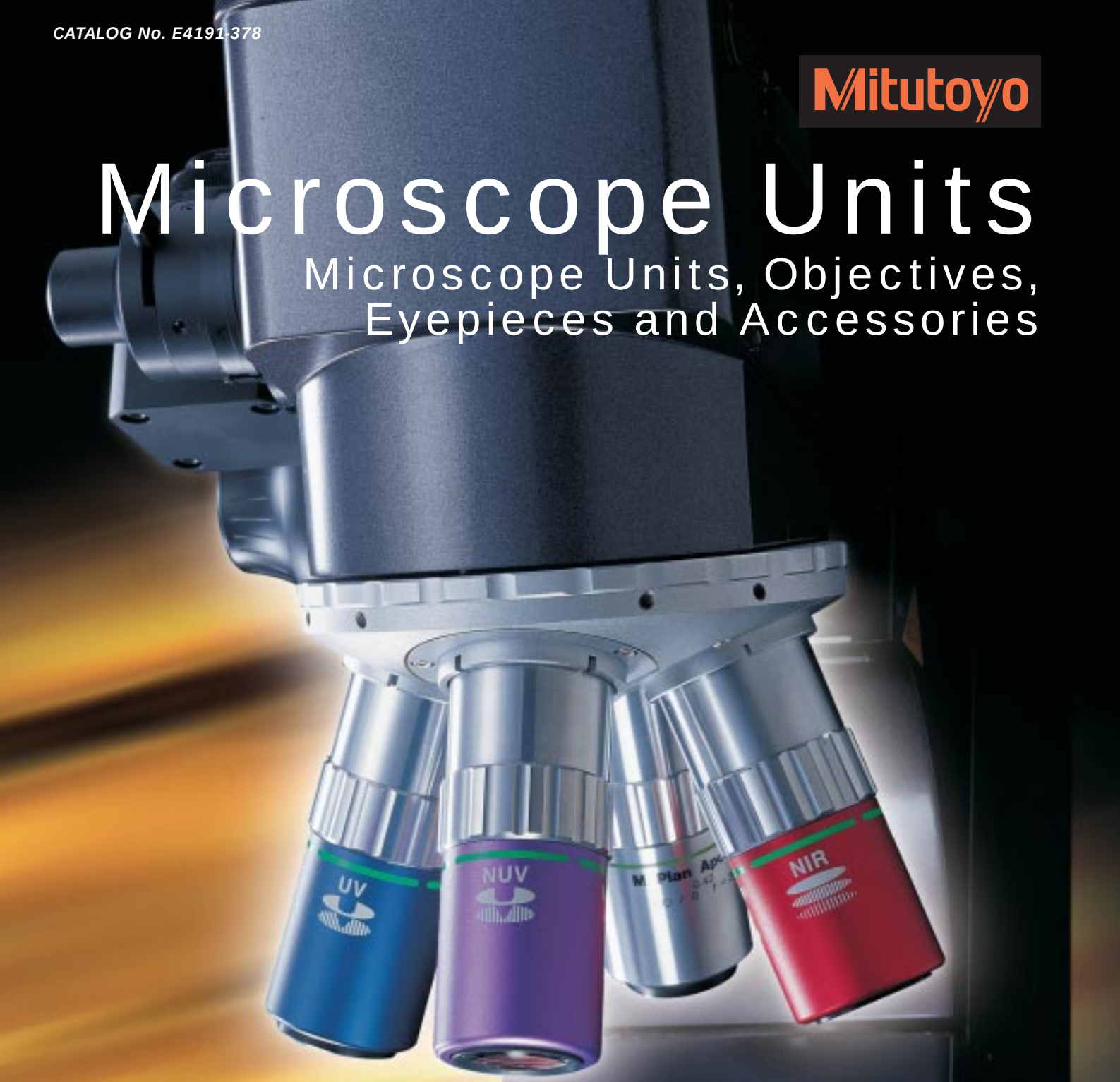
CATALOG No. E4191-378

Mitutoyo

Microscope Units

Microscope Units, Objectives, Eyepieces and Accessories

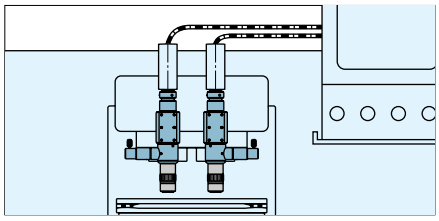


Mitutoyo long working distance objective for various observation demands.

The ultra-microscopic manufacturing technologies in the industrial world today require accuracy in the units of sub-microns. Mitutoyo has been introducing a series of microscope units with various features, combining the optical technologies developed by us and the precision measurement technologies developed over a long period of time. Mitutoyo microscopes can be integrated into systems like a various manufacturing equipment, research and development equipment, and product inspection equipment. Contact your nearest Mitutoyo office for detail specifications not included in this catalog, as well as for design and production of microscopes that best fit your specifications.

1. *Microscope unit for system integration*
VMU

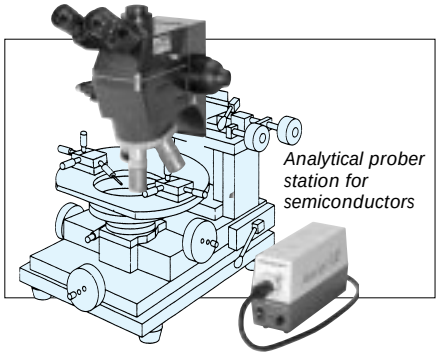
- ***Lightweight, small-size microscope unit for monitor system***
- ***Used together with an image-processing device, it can perform dimensional measurement, contour inspection, positioning, etc.***
- ***A new line of models for YAG Laser is now available, for cutting thin-films in semiconductors, liquid crystal substrates, and such.***



Semiconductor-mask positioning system

2. *High power microscope unit*
FS70

- ***The FS70 series can provide the erect image with a maximum magnification of 4,000x to facilitate operation. It is ideal for a prober station for semiconductors.***
- ***In addition to the standard inward-revolver optional revolvers with the center-adjustment and parfocal mechanisms are available.***
- ***For bright field, Differential Interference Contrast (DIC) and polarized observations. (The FS70L and FS70L4 do not support DIC observation.)***
- ***The FS70L and FS70L4 can be equipped with YAG Laser to cut semiconductor circuits and repair liquid crystal substrates.***



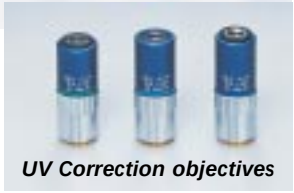
Analytical prober station for semiconductors

3. *Long working distance objectives*
M Plan Apo

- ***A specimen with steps that cannot be focused on with the conventional short working distance objectives, can be easily observed with the use of Mitutoyo long working distance objectives (e.g. 200x objective: 13mm).***
- ***The M Plan Apo (Apochromat) is an excellent optical system, with the flat and chromatic aberration free image over the entire field of view.***
- ***Various objectives for a wide range of light wavelengths, from near-infrared to ultraviolet radiation, are available: the near-infrared radiation corrected objectives for laser-cutting applications; the near-ultraviolet radiation corrected objectives; and the glass-thickness compensation objectives that allow observation of a vacuum furnace interior through a glass, for example.***
- ***Taking eco-friendliness into account, the Mitutoyo microscope lens (Order No. 378-XXX-3) employs environmentally friendly glass as the lens material (it has no lead or arsenic).***

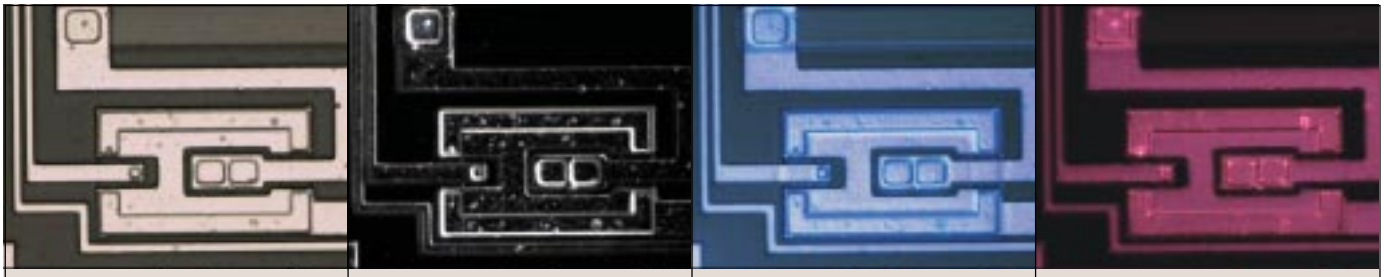
NIR Correction objectives

NOV Correction objectives



UV Correction objectives

Various observation methods



Bright field
A general observation method. A reflective light from the specimen is used for observation.

Dark field
A effective observation method for observing scratches, dust, and uneven surfaces. This method is also used for specimens with a low reflective rate.

Differential Interference Contrast (DIC) method
Since this method offers excellent depth detection, it is most ideal for observations of metal, crystal, semiconductor, etc. with ultra-small scratches, steps, and uneven surfaces.

Polarization
This method is used to observe optical characteristics of minerals, plastics, and liquid crystals.

Contents

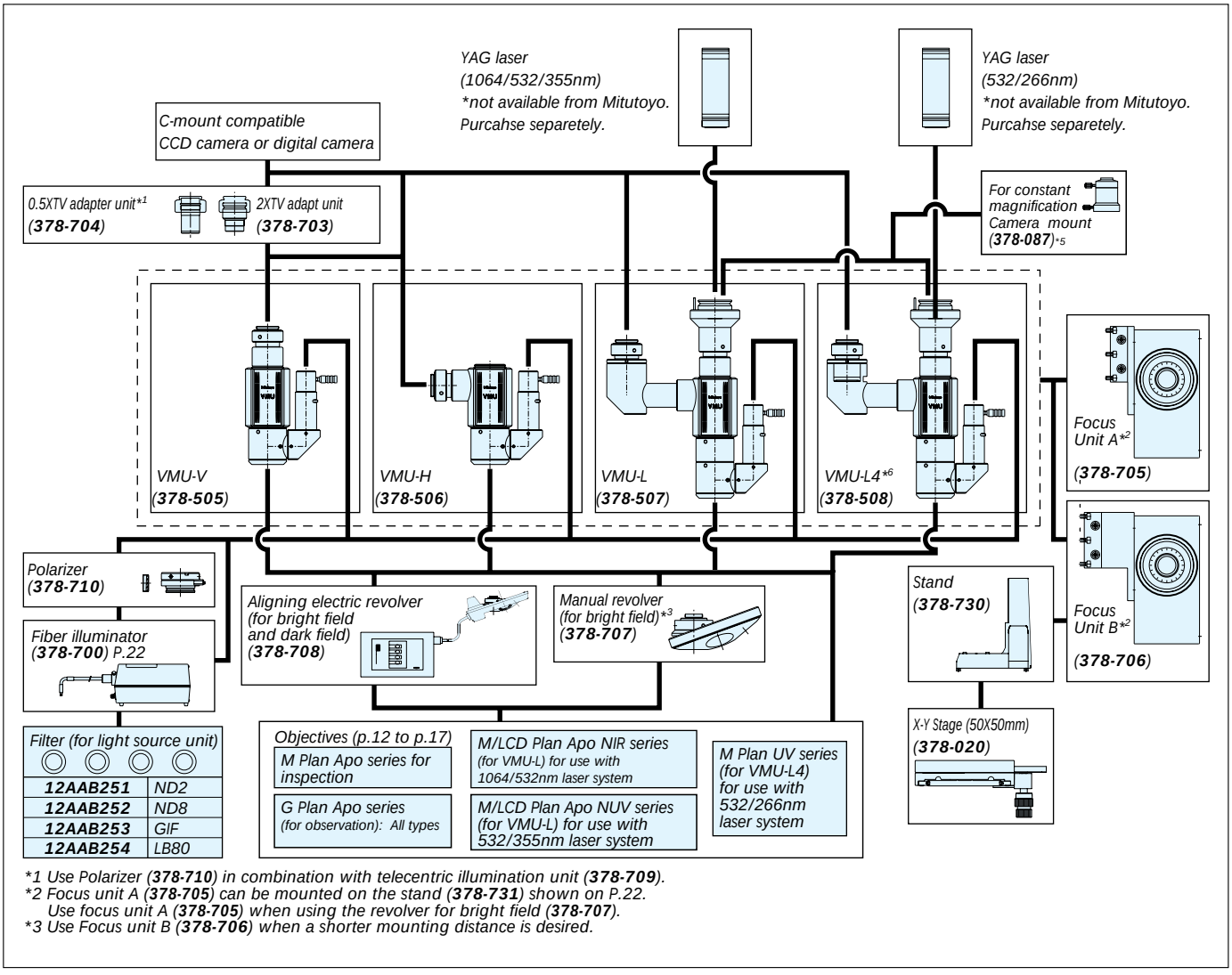
Video Microscope Unit

VMU

■ FEATURES

1. Small, lightweight microscope unit with a high performance-cost ratio. This unit is used as an integrated part of an TV observation system.
2. For a wide range of laser applications, such as laser-cutting fine-films of semiconductors and of liquid crystal substrates. The optical systems of the VMU support ranges of laser wavelengths: the VMU-

■ SYSTEM CONFIGURATION



*1 Use Polarizer (**378-710**) in combination with telecentric illumination unit (**378-709**).
*2 Focus unit A (**378-705**) can be mounted on the stand (**378-731**) shown on P.22.
Use focus unit A (**378-705**) when using the revolver for bright field (**378-707**).
*3 Use Focus unit B (**378-706**) when a shorter mounting distance is desired.

■ SPECIFICATIONS

Model No.		VMU-V	VMU-H	VMU-L-1	VMU-L4-1
Order No.		378-505	378-506	378-507	378-508
Camera mount		Vertical	Horizontal	Vertical	
Observation image		BF/erect image	BF/inverted image	BF/erect image	BF/erect image
Optical tube	TV adapter	with C-mount & centering mechanism			with green filter switch
	Tube lens (correction)	1x (near-infrared and visible radiation)		1x (near-infrared - visible - near-ultraviolet radiation)	1x (visible and ultraviolet radiation)
	Applicable laser	—		1064/532/355nm YAG laser	532/266nm YAG laser
Objectives (optional)	For observation	M Plan Apo-2, M Plan Apo SL, G Plan Apo			
	For laser-cutting	—		M/LCD Plan Apo NIR-3, M/LCD Plan Apo NUV-3	M Plan UV
Applicable camera		1/2 inch or smaller CCD camera (C-mount type)			
Illumination system		Telecentric reflective illumination (with aperture diaphragm)			
Mass		570g	590g	980g	1010g

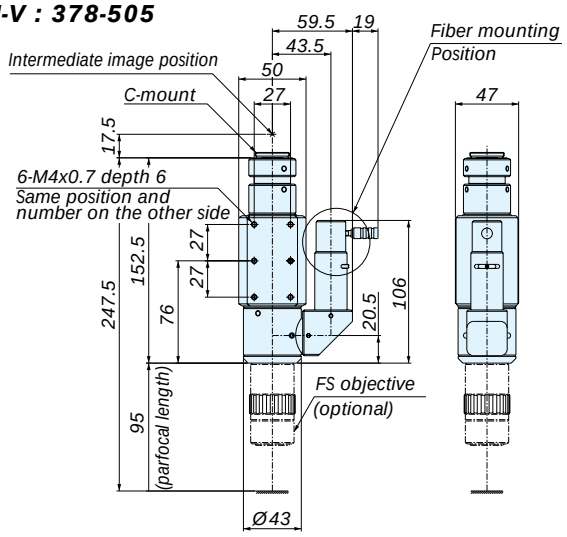
-1: When using the VMU-L or -L4 with a laser system, refer to "Cautions in using microscope with YAG laser system" on P.27.
-2: M Plan Apo 1x should be used together with the polarizer (**378-710**).
-3: Select model depending on the type of laser wavelength.

L supports principle wavelength (1064nm: near-infrared), 2nd harmonic generation SHC (532nm: visible) and 3rd harmonic generation THD (355nm: near-ultraviolet) YAG lasers; the VMU-L4 supports 2nd harmonic generation SHC and 4th harmonic generation FHC (266nm: ultraviolet) YAG lasers. However, Mitutoyo assumes no responsibility whatsoever for the performance and/or safety of the laser system used with Mitutoyo microscopes. A careful examination is recommended in selecting a laser emission unit.

3. *Various optional accessories are available for various combinations: Revolver for bright field observation, C-mount adapter unit (0.5x/2x), Polarizer, etc.*
4. *The Telecentric illumination unit with aperture diaphragm is ideal for a image processing that requires a depolarized illumination.*

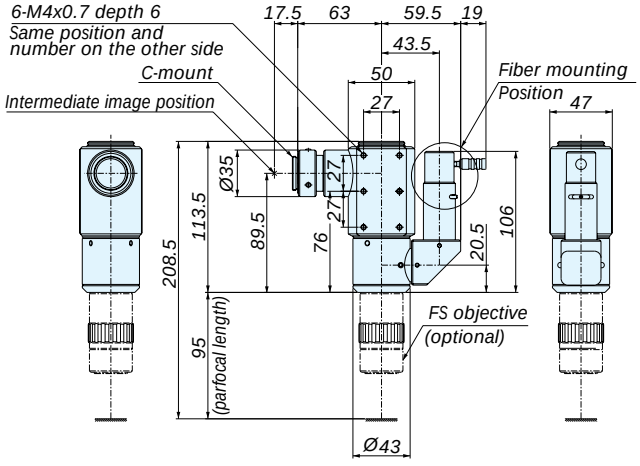
■ DIMENSIONS

VMU-V : 378-505

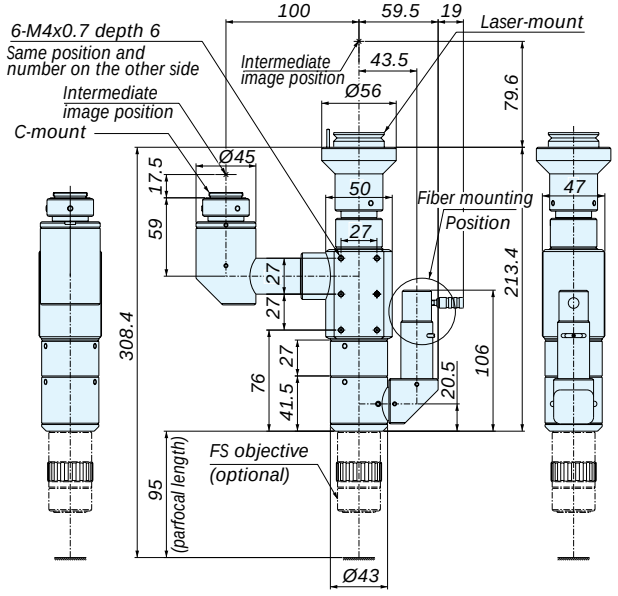


VMU-H : 378-506

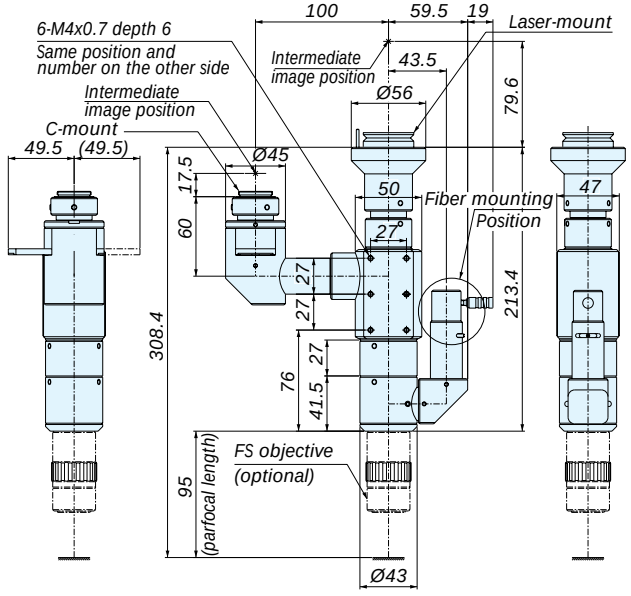
Unit: mm

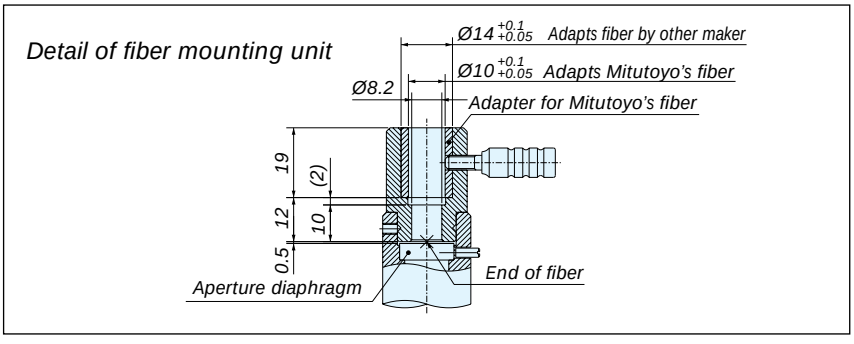


VMU-L : 378-507



VMU-L4 : 378-508



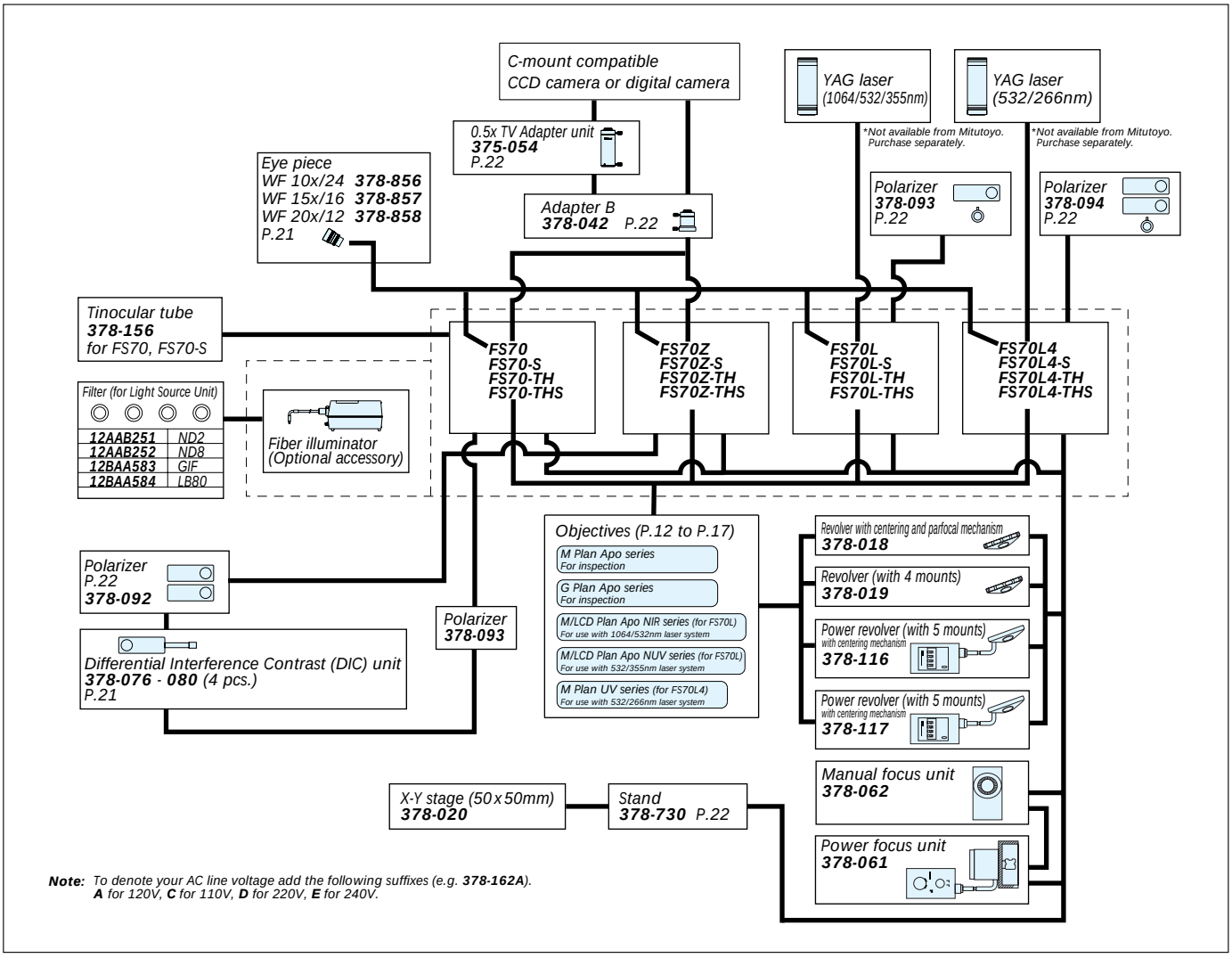


FS70

■ FEATURES

1. It is ideal as a microscope unit of a prober station for semiconductors. (All models CE marked.)
2. The FS70L supports three types of YAG laser wavelength ranges (1064nm, 532nm and 355nm), while the FS70L4 supports two types of wavelength ranges (532nm and 266nm), thus expanding a scope of laser applications, allowing laser-cutting of thin-films used in semiconductors and liquid crystal substrates.

■ SYSTEM CONFIGURATION



Note: To denote your AC line voltage add the following suffixes (e.g. **378-162A**).
A for 120V, **C** for 110V, **D** for 220V, **E** for 240V.

■ AVAILABLE MODELS

Basic models
FS70:
with standard base
FS70-S:
with short base
FS70-TH:
with tilting head and standard base
FS70-THS:
with tilting head and short base

1x - 2x zoom models
FS70Z:
with standard base
FS70Z-S:
with short base
FS70Z-TH:
with tilting head and standard base
FS70Z-THS:
with tilting head and short base

1064nm/532nm/355nm laser models
FS70L:
with standard base
FS70L-S:
with short base
FS70L-TH:
with tilting head and standard base
FS70L-THS:
with tilting head and short base

532nm/266nm laser models
FS70L4:
with standard base
FS70L4-S:
with short base
FS70L4-TH:
with tilting head and standard base
FS70L4-THS:
with tilting head and short base

However, Mitutoyo assumes no responsibility whatsoever for the performance and/or safety of the laser system used with Mitutoyo microscopes. A careful examination is recommended in selecting a laser-emission unit.

3. Bright field, Differential Interference Contrast (DIC) and polarized observations are standard with the FS70Z. The FS70L and FS70L4 do not support the DIC method. The FS70ZD, which supports dark-field observation, is also available.

■ SPECIFICATIONS

Model No. / **Order No.**	**FS70** / **378-184-1**	**FS70-TH** / **378-184-3**	**FS70Z** / **378-185-1**	**FS70Z-TH** / **378-185-3**
Model No. / **Order No.**	**FS70-S** / **378-184-2**	**FS70-THS** / **378-184-4**	**FS70Z-S** / **378-185-2**	**FS70Z-THS** / **378-185-4**
Focus adjustment	With concentric coarse and fine focusing wheels (right and left) (50mm travel range, 0.1mm/rev. for fine adjustment, 3.8mm/rev. for coarse adjustment)			
Trinocular tube Image	Erect image			
Pupil distance	Siedentopf type, adjustment range: 51 - 76mm			
Field number	24			
Tilt angle	0º - 20º (only -TH, -THS models)			
Optical pass ratio	50/50[-1]	100/0 or 0/100[-2]	50/50[-1]	100/0 or 0/100[-2]
Protective filter	—			
Main unit Tube lens	1x		1x -2x zoom	
Applicable YAG laser	1064/532/355nm (when using optional tube)		—	
Camera mount	Adapter B (C-mount)[-3]			
Illumination system	Reflective illumination for bright field (Koehler illumination, with aperture diaphragm)			
Light source[-3]	12V100W fiber optics, (non-stepped adjustment), light guide length 1.5m, power consumption 150W			
Objectives[-3] For observation	M Plan Apo[-4], M Plan Apo SL, G Plan Apo			
For laser-cutting	—			
Loading weight on optical tube[-6]	14.5kg	13.6kg	14.1kg	13.2kg
Mass (main unit)	6.1kg	7.1kg	6.6kg	7.5kg

When using the FS70L or -L4 with a laser system, refer to "Cautions in using microscope with YAG laser system" on P.27.

-1: Eyepiece/CCD camera

-2: Eyepiece/laser

-3: Optional

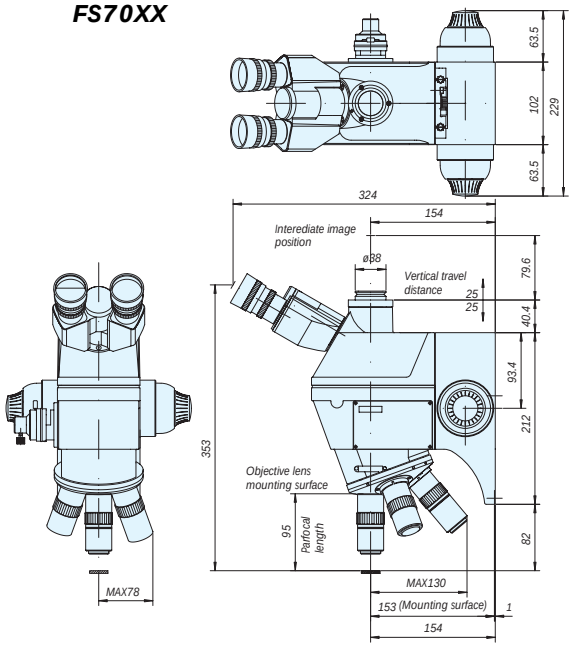
*-4: M Plan Apo 1x should be used together with the the polarizer (**378-092**).*

-5: Select model depending on the type of laser wavelength.

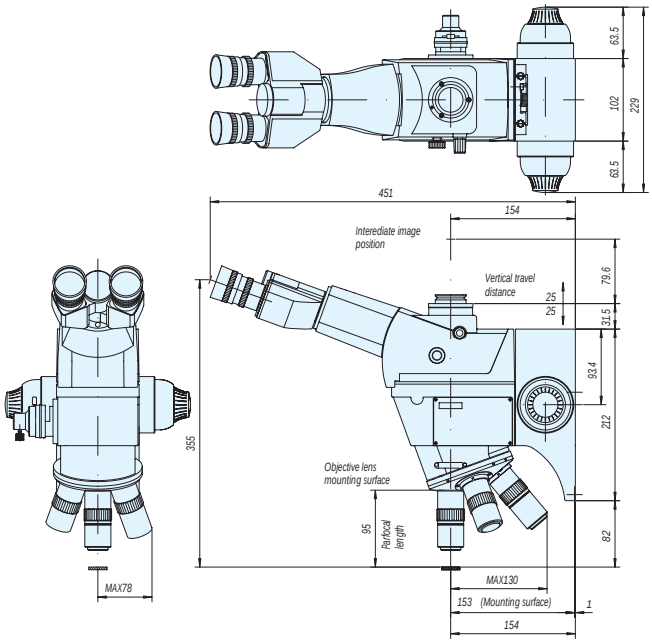
-6: Weight of objective lenses and eyepieces not included.

■ DIMENSIONS

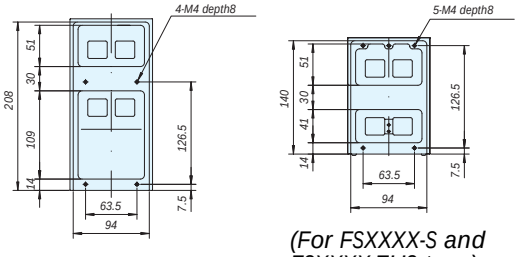
FS70XX



FS70XX-TH



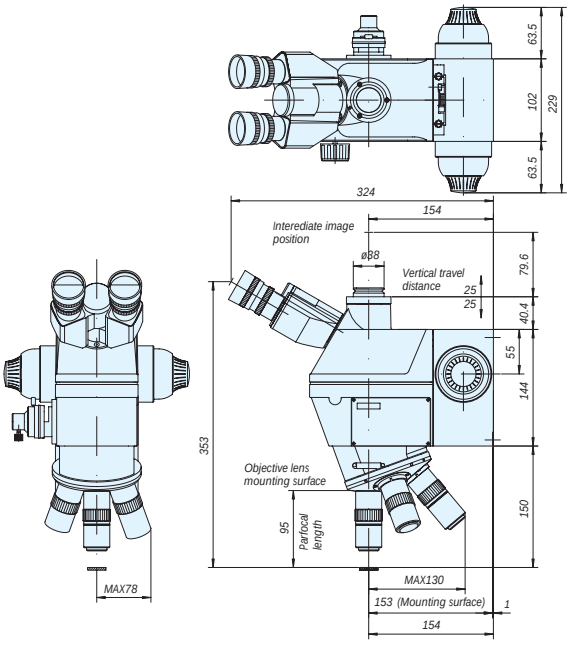
Mounting-screw hole positions on the base (for all models)



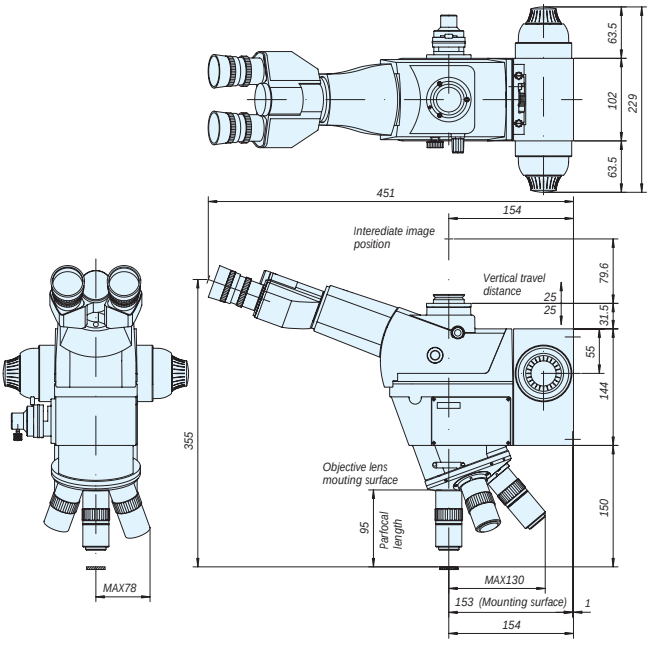
(For FSXXXX-S and FSXXXX-THS type)

FS70XX-S

Unit: mm



FS70XX-THS



4. *By employing an inward revolver, the long working distance objectives provide excellent operatability.*
5. *An ergonomic design with superb operatability: the FS70 employs the erect-image optical system (the image in the field of view has the same orientation as the specimen) and enlarged fine focus adjustment wheel with rubber grip coarse adjustment knob.*

FS70L 378-186-1	**FS70L-TH 378-186-3**	**FS70L4 378-187-1**	**FS70L4-TH 378-187-3**
FS70L-S 378-186-2	**FS70L-THS 378-186-4**	**FS70L4-S 378-187-2**	**FS70L4-THS 378-187-4**
With concentric coarse and fine focusing wheels (right and left) (50mm travel range, 0.1mm/rev. for fine adjustment, 3.8mm/rev. for coarse adjustment)			
Erect image			
Siedentopf type, adjustment range: 51 - 76mm			
24			
0º - 20º (only -TH, -THS models)			
100/0 or 0/100[-2]			
Built-in laser beam filter			
1x			
1064/532/355nm		*532/266nm*	
— *(use a laser with the TV port.)*		*C-mount receptacle (with green filter switch)*	
Reflective illumination for bright field (Koehler illumination, with aperture diaphragm)			
12V100W fiber optics, (non-stepped adjustment), light guide length 1.5m, power consumption 150W			
M Plan Apo[-4], M Plan Apo SL, G Plan Apo			
M/LCD Plan Apo NIR[-5], M/LCD Plan Apo NUV[-5]		*M Plan UV*	
14.5kg	*13.6kg*	*14.1kg*	*13.2kg*
6.1kg	*7.1kg*	*6.6kg*	*7.5kg*

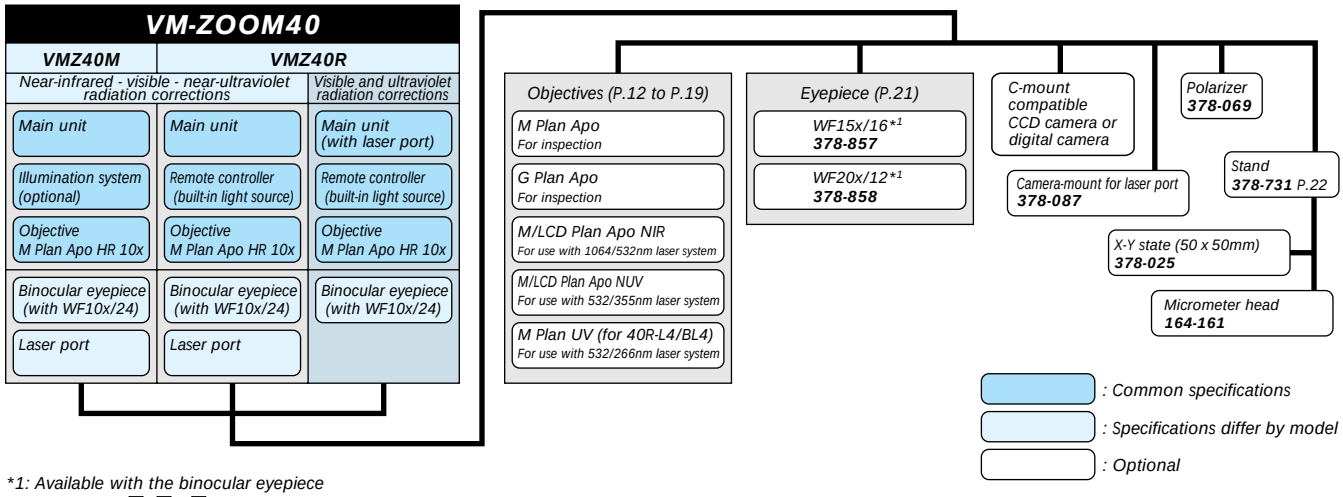
Zoom Video Microscope Unit

VM-ZOOM

■ FEATURES

1. The VM-ZOOM is a microscope unit with the high-zoom function. Like the FS70, it is ideal as an optical unit of a prober station for semiconductors.
2. Equipped with the built-in zoom lens with a magnification of 0.25x - 10x and the special high N.A. objective, the VM-Zoom offers a continuous image of 100 - 4000x on a 15" monitor.
3. There are a total of 10 models to choose from. Choose a model, combining it with the binocular eyepiece, the power zoom system, or YAG laser with a specific wavelength, depending on the specifications required for the purpose.

■ SYSTEM CONFIGURATION



*1: Available with the binocular eyepiece
*2: For VMZ40 ☐-☐L☐ type (YAG laser mountable). A 20x or 50x objective is recommended.
*3: By mounting on the laser port it allows the inspector to confirm the current position of the specimen observed by the zoom lens.
For VMZ40 ☐-☐L☐ type (YAG laser mountable). Use a 2/3" CCD camera or smaller (C-mount type).

■ SPECIFICATIONS

Note: To denote your AC line voltage add the following suffixes (e.g. **378-171A**).
A for 120V, **C** for 110V, **D** for 220V, **E** for 240V. **No suffix** is required for 100V

Model No	VMZ40M	VMZ40M-L	VMZ40M-B	VMZ40M-BL	VMZ40R	VMZ40R-L	VMZ40R-B	VMZ40R-BL	VMZ40R-L4	VMZ40R-BL4
Order No.	378-171	378-173	378-172	378-174	378-175	378-177	378-176	378-178	378-181	378-182
Radiation range	Near-infrared - Visible - Near-ultraviolet								Visible and Ultraviolet	
Zoom type	Manual				Power drive					
Image	Bright field/erect image									
Main unit mag.	0.25x - 10x (Zoom ratio: 40)									
Total mag.	100x - 4000x (when using 10x objective, 1/2 inch CCD camera and 15" monitor)									
Observation range (when using 10x objective)	1/2 inch CCD camera: 2.56x1.92mm - 0.064x0.048mm Eyepiece (WF10x/24): Ø3.2mm - Ø0.08mm									
Eyepiece lens	—		10x, 15x, 20x		—		10x, 15x, 20x		—	10x, 15x, 20x
Objective-1 Observation	M Plan Apo, G Plan Apo									
Laser-cutting-2	—	M/LCD Plan Apo NIR	—	M/LCD Plan Apo NIR	—	M/LCD Plan Apo NIR	—	M/LCD Plan Apo NIR	—	M Plan UV
	—	M/LCD Plan Apo NUV	—	M/LCD Plan Apo NUV	—	M/LCD Plan Apo NUV	—	M/LCD Plan Apo NUV		
Focus adjustment	With concentric coarse and fine focusing wheels (right and left) (50mm travel range, 0.1mm/rev. for fine adjustment, 3.8mm/rev. for coarse adjustment)									
Illumination system	Optional				Built-in remote controller with Auto-brightness control (2m light guide, 21V, 150W Halogen bulb (215390) bulb life 200H)					
Revolver	for BF lens (1 mount)	for BF lens (2 mounts) with centering mechanism			for BF lens (1 mount)	for BF lens (2 mounts) with centering mechanism				
TV adapter	with C-mount & centering mechanism								with green filter switch	
Camera	1/2 inch or smaller CCD camera (C-mount type)									
Power consumption	—				200W					
Mass (main unit)	6.5kg	7.0kg	7.5kg	8.0kg	7.0kg	7.5kg	8.0kg	8.5kg	7.5kg	8.5kg

* When using the VM-ZOOM with a laser system, refer to "Cautions in using microscope with YAG laser system" on P.27.
-1: When using an objective other than the one that is a standard accessory, there may be times when the observation image of the specimen is not bright enough, depending on what type of specimen. A magnification of 2x - 50x is recommended.
-2: Select model depending on the type of laser wavelength.

4. *Equipped with a unique sliding revolver, to which an additional NIR/NUV/UV objective, as well as the 10x standard objective can be attached, for processing thin-films in semiconductors and liquid crystal substrates. However, Mitutoyo assumes no responsibility whatsoever for the performance and/or safety of the laser system used with Mitutoyo microscopes. A careful examination is recommended in selecting a laser system.*
5. *Customized specifications, such as polarization and Differential Interference Contrast observations, and a guaranteed magnification system (for power zoom type only) are also available.*

VMZ40 □ – □ □

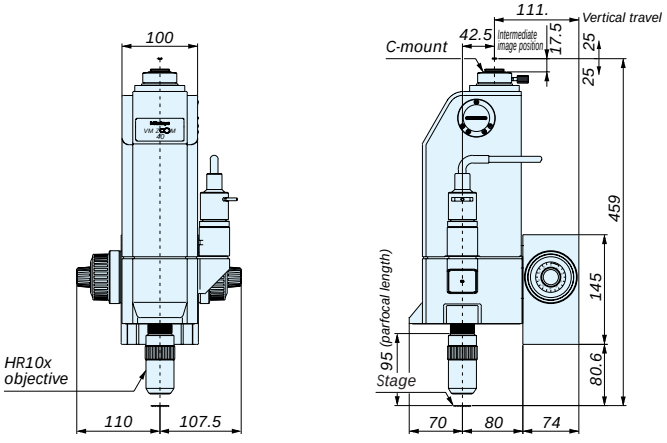
R : *Power zoom*
M : *Manual zoom*

B : *With binocular eyepiece*

L : *YAG laser system (1064/532/355nm) can be attached*
L4 : *YAG laser system (532/266nm) can be attached*

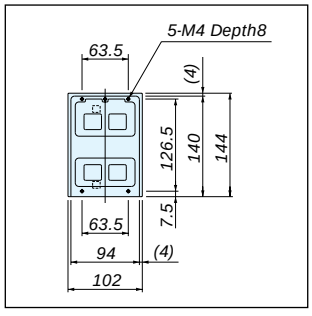
■DIMENSIONS

VMZ40M : 378-171

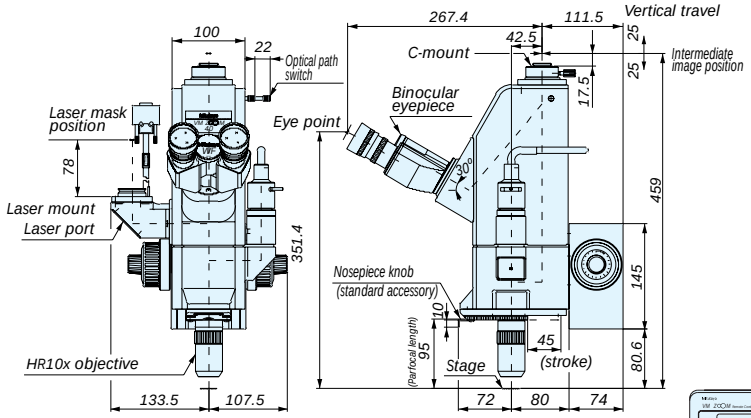


Mounting-screw hole positions on main unit (for all models)

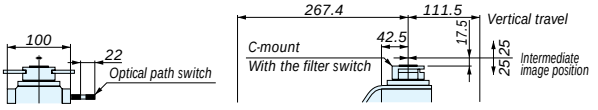
Unit: mm



VMZ40R-BL : 378-178

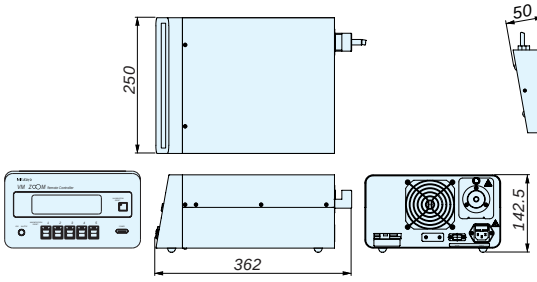


VMZ40R-BL4 : 378-182 (shown only the TV-mount section)*

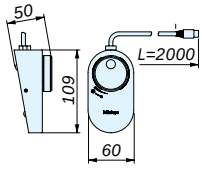


**VMZ40R-BL4 has the same specifications as the VMZ40R-BL, except for the specifications of the TV-mount section.*

Remote controller



Jog-shuttle dial



Weight: Approx. 7kg
(Remote controller and jog-shuttle dial combined)

Long working distance objectives for bright field

M Plan Apo

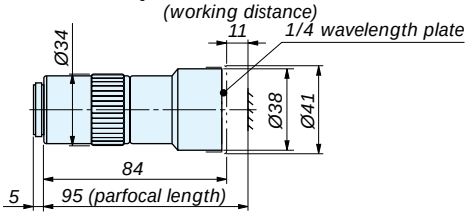
FEATURES

1. A specimen with steps, which cannot be focused on with the conventional short working distance objectives, can be easily observed with the use of Mitutoyo long working distance objectives (M Plan Apo 100x: 6mm).
2. The M Plan Apo (Apochromat) is an excellent optical system, with the flat and chromatic aberration free image over the entire field of view.

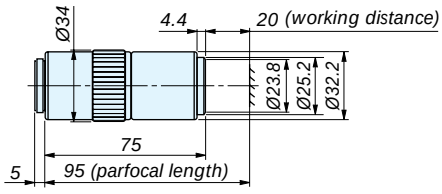
DIMENSIONS

*Mounting screws 26, thread 36 (see P.30.)

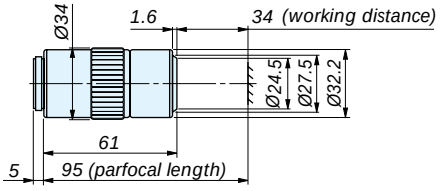
M Plan Apo 1x : 378-800



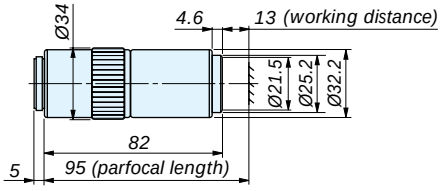
M Plan Apo 20x : 378-804-2



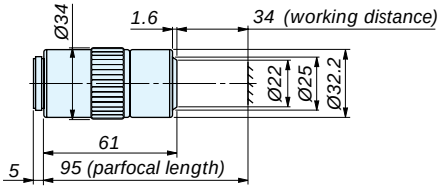
M Plan Apo 2x : 378-801



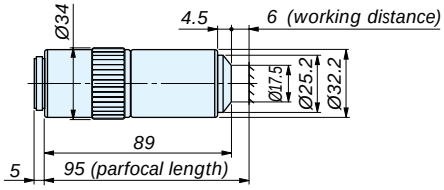
M Plan Apo 50x : 378-805-2



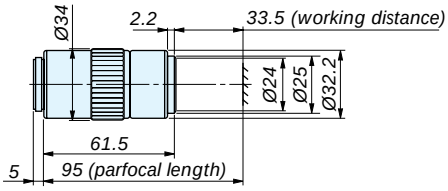
M Plan Apo 5x : 378-802-2



M Plan Apo 100x : 378-806-3



M Plan Apo 10x : 378-803-2



Unit: mm

SPECIFICATIONS

Order No.	Magnification	N.A.	W.D. (mm)	S (mm)	R (μm)	DOF (μm)	Real FOV (mm) (Ø24 eyepiece)	Real FOV (VxH, mm) (1/2" CCD camera)	Mass (g)
378-800*	1x	0.025	11.0	200	11.0	440	Ø24	4.8x6.4	300
378-801	2x	0.055	34.0	100	5.0	91	Ø12	2.4x3.2	220
378-802-2	5x	0.14	34.0	40	2.0	14.0	Ø4.8	0.96x1.28	230
378-803-2	10x	0.28	33.5	20	1.0	3.5	Ø2.4	0.48x0.64	230
378-804-2	20x	0.42	20.0	10	0.7	1.6	Ø1.2	0.24x0.32	370
378-805-2	50x	0.55	13.0	4	0.5	0.9	Ø0.48	0.10x0.13	290
378-806-3	100x	0.70	6.0	2	0.4	0.6	Ø0.24	0.05x0.06	320

* M Plan Apo 1x (**378-800**) should be used together with an appropriate polarizer for the microscope used.
•The resolving power and focal depth of the discrete objective are values determined based on the reference wavelength.

Super-long working distance objectives for bright field

M Plan Apo SL

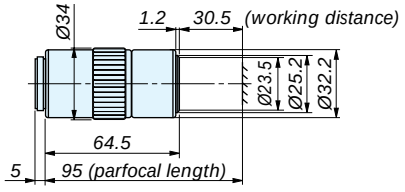
■ FEATURES

1. Super-long working distance objectives (M Plan Apo SL200x: 13mm) for bright field observation.
2. The M Plan Apo (Apochromat) is an excellent optical system, with the flat and chromatic aberration free image over the entire field of view.

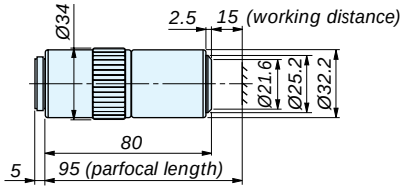
■ DIMENSIONS

*Mounting screws 26, thread 36 (see P.30.)

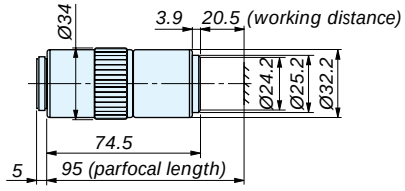
M Plan Apo SL20x : 378-810-3



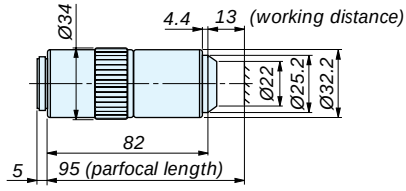
M Plan Apo SL80x : 378-812-3



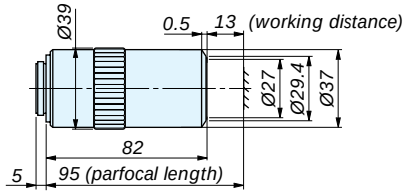
M Plan Apo SL50x : 378-811-3



M Plan Apo SL100x : 378-813-3



M Plan Apo SL200x : 378-816-3



Unit: mm

■ SPECIFICATIONS

Order No.	Magnification	N.A.	W.D. (mm)	S (mm)	R (μm)	DOF (μm)	Real FOV (mm) (Ø24 eyepiece)	Real FOV (VxH, mm) (1/2" CCD camera)	Mass (g)
378-810-3	20x	0.28	30.5	10	1.0	3.5	Ø1.2	0.24x0.32	240
378-811-3	50x	0.42	20.5	4	0.7	1.6	Ø0.48	0.10x0.13	280
378-812-3	80x	0.50	15.0	2.5	0.6	1.1	Ø0.30	0.06x0.08	280
378-813-3	100x	0.55	13.0	2	0.5	0.9	Ø0.24	0.05x0.06	290
378-816-3	200x	0.62	13.0	1	0.4	0.7	Ø0.12	0.025x0.03	490

•The resolving power and focal depth of the discrete objective are values determined based on the reference wavelength.

High-resolving power objectives for bright field

M Plan Apo

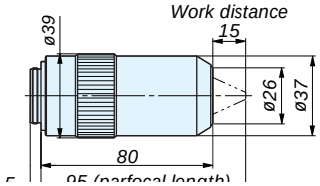
■ FEATURES

1. High resolving power objectives (M Plan Apo 100x: N.A. 0.90) for bright field observation.
2. The M Plan Apo (Apochromat) is an excellent optical system, with the flat and chromatic aberration free image over the entire field of view.

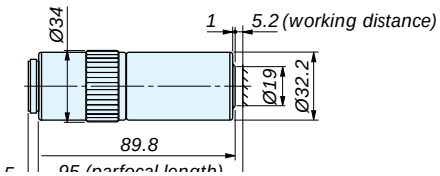
■ DIMENSIONS

*Mounting screws 26, thread 36 (see P.30.)

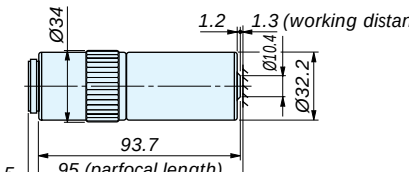
M Plan Apo HR 10x : 378-788-4



M Plan Apo 50x : 378-814-4



M Plan Apo 100x : 378-815-4



Unit: mm

■ SPECIFICATIONS

Order No.	Magnification	N.A.	W.D. (mm)	S (mm)	R (μm)	DOF (μm)	Real FOV (mm) (Ø24 eyepiece)	Real FOV (VxH, mm) (1/2" CCD camera)	Mass (g)
378-788-4	10x	0.42	15	20	0.6	1.55	Ø2.4	0.48x0.64	460
378-814-4*	50x	0.75	5.2	4	0.4	0.48	Ø0.48	0.10x0.13	400
378-815-4*	100x	0.90	1.3	2	0.3	0.34	Ø0.24	0.05x0.06	410

* Available on "made-to-order" basis.
•The resolving power and focal depth of the discrete objective are values determined based on the reference wavelength.

Objectives with glass-thickness compensation for bright field

G Plan Apo

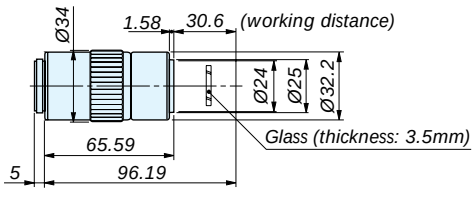
■ FEATURES

1. Long working distance objectives (G Plan Apo 50x: 13.89mm) for bright field observation. These objectives allow observation of a specimen through a glass; they can be used to observe a specimen in a laboratory dish, a vacuum furnace, or various glass chambers.
2. Designed to correct a glass thickness of 3.5mm*.
3. The M Plan Apo (Apochromat) is an excellent optical system, with the flat and chromatic aberration free image over the entire field of view.

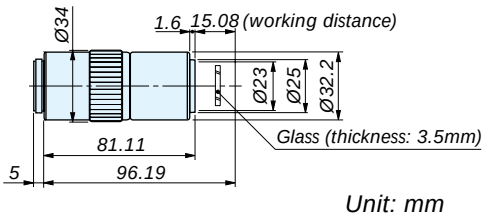
■ DIMENSIONS

*Mounting screws 26, thread 36 (see P.30.)

G Plan Apo 20x : 378-847



G Plan Apo 50x : 378-848



Unit: mm

■ SPECIFICATIONS

Order No.	Magnification	N.A.	W.D.** (mm)	S (mm)	R (μm)	DOF (μm)	Real FOV (mm) (Ø24 eyepiece)	Real FOV (VxH, mm) (1/2" CCD camera)	Mass (g)
378-847*	20x	0.28	29.42	10	1.0	3.5	Ø1.2	0.24x0.32	270
378-848-3	50x	0.50	13.89	4	0.6	1.1	Ø0.48	0.10x0.13	320

* Available on "made-to-order" basis.
** Air conversion
•The resolving power and focal depth of the discrete objective are values determined based on the reference wavelength.

Objectives with near-infrared radiation correction for bright field

M Plan Apo NIR

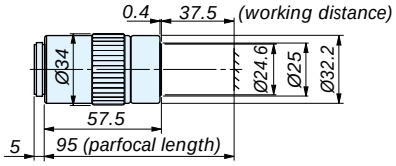
■ FEATURES

1. Long working distance objectives (M Plan Apo NIR 100x: 12mm) for bright field in laser cutting.
2. Designed to focus within the depth of focus, even when the laser wavelength used changes from the visible radiation (general inspection range) to the near-infrared radiation range (wavelength 1800nm).
3. Designed to improve the spectral transmission factor within near-infrared radiation. Most ideal when attached to the FS70L, VMU-L, or VMZ40 and used together with YAG laser (wavelength 1064nm), for cutting semiconductor circuits.

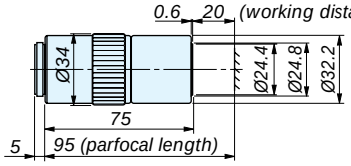
■ DIMENSIONS

*Mounting screws 26, thread 36 (see P.30.)

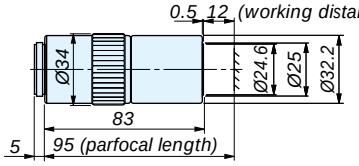
M Plan Apo NIR 5x : 378-822-4



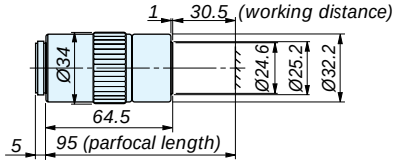
M Plan Apo NIR 20x : 378-824-4



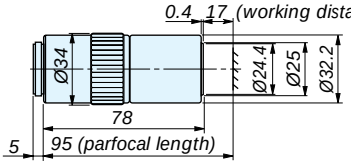
M Plan Apo NIR 100x : 378-826-5



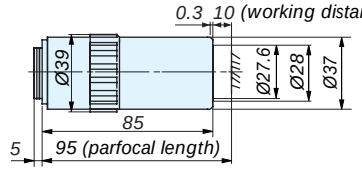
M Plan Apo NIR 10x : 378-823



M Plan Apo NIR 50x : 378-825-1



M Plan Apo NIR-HR 50X/100X : 378-863-5/ 864-5



*Depending on the focal point of the visible ray, when the wavelength exceeds 1100nm, a glass variance or an error that occurs in a measurement of the refractive index may cause the focus to shift.

■ SPECIFICATIONS

Unit: mm

Order No.	Magnification	N.A.	W.D. (mm)	S (mm)	R (μm)	DOF (μm)	Real FOV (mm) (Ø24 eyepiece)	Real FOV (VxH, mm) (1/2" CCD camera)	Mass (g)
378-822-4	5x	0.14	37.5	40	2.0	14.0	Ø4.8	0.96x1.28	220
378-823-4	10x	0.26	30.5	20	1.1	4.1	Ø2.4	0.48x0.64	250
378-824-4	20x	0.40	20.0	10	0.7	1.7	Ø1.2	0.24x0.32	300
378-825-5	50x	0.42	17.0	4	0.7	1.6	Ø0.48	0.10x0.13	315
378-826-5	100x	0.50	12.0	2	0.6	1.1	Ø0.24	0.05x0.06	335
378-863-5	50x	0.65	10.0	4	0.42	0.65	Ø0.48	0.10x0.13	450
378-864-5	100x	0.70	10.0	2	0.39	0.56	Ø0.24	0.05x0.06	450

•The resolving power and focal depth of the discrete objective are values determined based on the reference wavelength.

Objectives with near-infrared radiation correction, for bright field through liquid crystal

LCD Plan Apo NIR

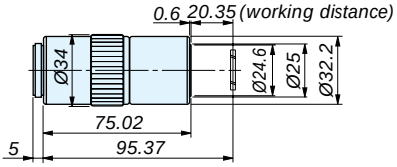
■ FEATURES

1. Long working distance objectives (LCD Plan Apo NIR 50x/t0.7: 17.26mm) designed for bright field observation through a glass in laser cutting.
2. These objectives correct the near-infrared radiation to be used for observation through a liquid crystal (thickness 1.1mm or 0.7mm) or for repair with a laser. Design and production of this type of lens with different glass thickness are also available.

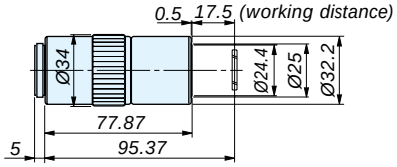
■ DIMENSIONS

*Mounting screws 26, thread 36 (see P.30.)

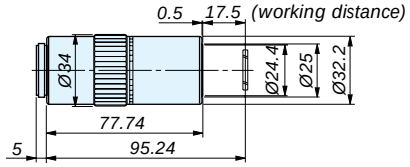
LCD Plan Apo NIR 20x/t1.1 : 378-827-4



LCD Plan Apo NIR 50x/t1.1 : 378-828-5



LCD Plan Apo NIR 50x/t0.7 : 378-829-5



■ SPECIFICATIONS

Unit: mm

Order No.	Magnification/ glass thickness	N.A.	W.D.** (mm)	S (mm)	R (μm)	DOF (μm)	Real FOV (mm) (Ø24 eyepiece)	Real FOV (VxH, mm) (1/2" CCD camera)	Mass (g)
378-827-4	20x/t1.1	0.40	19.98	10	0.7	1.7	Ø1.2	0.24x0.32	305
378-828-4	50x/t1.1	0.42	17.13	3.9	0.7	1.6	Ø0.48	0.10x0.13	320
378-829-5*	50x/t0.7	0.42	17.26	3.9	0.7	1.6	Ø0.48	0.10x0.13	320

* Available on "made-to-order" basis.
** Air conversion
•The resolving power and focal depth of the discrete objective are values determined based on the reference wavelength.

Objectives with near-ultraviolet radiation correction for bright field

M Plan Apo NUV

Objectives with near-ultraviolet radiation correction for bright field through liquid crystal

LCD Plan Apo NUV

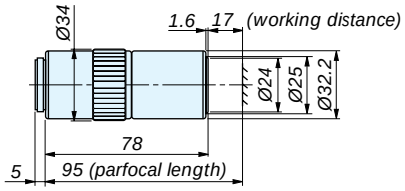
■ FEATURES

1. Long working distance objectives (M Plan Apo NUV 100x: 11mm) for bright field observation.
2. Designed to focus within the depth of focus, even when the laser wavelength used changes from the visible radiation (general inspection range) to the near-ultraviolet radiation range (wavelength 355nm).
3. These objectives correct the near-ultraviolet radiation to be used for observation or for repair with a laser through a liquid crystal (thickness 0.7mm).
4. Designed to improve the spectral transmission factor within near-ultraviolet radiation range. Most ideal when attached to the FS70L and used together with YAG laser (wavelength 355nm), for cutting semiconductor circuits, as well as repairing liquid crystal color filters.

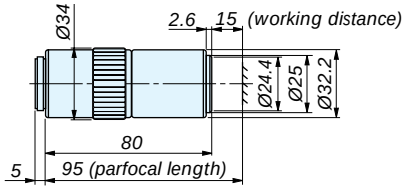
■ DIMENSIONS

*Mounting screws 26, thread 36 (see P.30.)

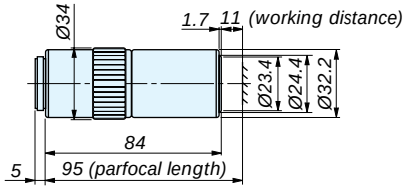
M Plan Apo NUV 20x : 378-817-4



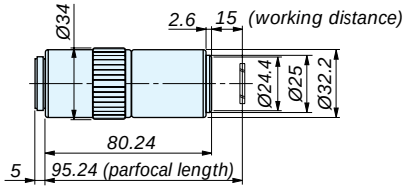
M Plan Apo NUV 50x : 378-818-4



M Plan Apo NUV 100x : 378-819-4



LCD Plan Apo NUV 50x/t0.7 : 378-820-4



Unit: mm

■ SPECIFICATIONS

Order No.	Magnification/ glass thickness	N.A.	W.D.** (mm)	S (mm)	R (μm)	DOF (μm)	Real FOV (mm) (Ø24 eyepiece)	Real FOV (VxH, mm) (1/2" CCD camera)	Mass (g)
378-817-4	20x	0.40	17.0	10	0.7	1.7	Ø1.2	0.24x0.32	340
378-818-4	50x	0.42	15.0	4	0.7	1.6	Ø0.48	0.10x0.13	350
378-819-4	100x	0.50	11.0	2	0.6	1.1	Ø0.24	0.05x0.06	380
378-820-4*	50x/t0.7	0.42	14.76	4	0.7	1.6	Ø0.48	0.10x0.13	310

* Available on "made-to-order" basis.
** For **378-802** is "Air conversion".
•The resolving power and focal depth of the discrete objective are values determined based on the reference wavelength.

M Plan UV

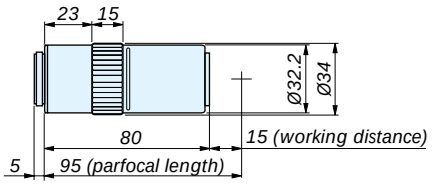
FEATURES

1. Long working distance objectives (M Plan UV 80x: 10mm) for bright field observation.
2. Designed to focus within the depth of focus, when either laser wavelength of the visible radiation (550nm) or ultraviolet radiation (266nm) is used. Improves the spectral transmission factors: 20x and 50x objectives by 80%, and 80x objective by 60% ultraviolet radiation.
3. Powerful when attached to the FS70L4, VMU-L4, VMZ40R-L4, or -BL4 and used together with YAG laser (wavelengths 532nm or 266nm), for cutting microscopic workpieces that require high-accuracy cutting, such as semiconductor protective film or semiconductor circuits.

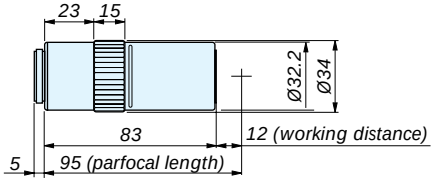
DIMENSIONS

*Mounting screws 26, thread 36 (see P.30.)

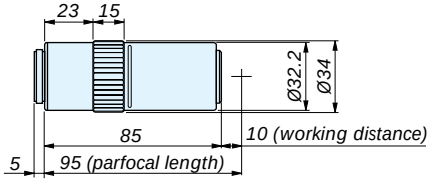
M Plan UV 20x : 378-837-5



M Plan UV 50x : 378-838-5



M Plan UV 80x : 378-839-5



Unit: mm

SPECIFICATIONS

Order No.	Magnification	N.A.	W.D. (mm)	S (mm)	R (μm)	DOF (μm)	Real FOV (mm) (Ø24 eyepiece)	Real FOV (VxH, mm) (1/2" CCD camera)	Mass (g)
378-837-5	20x	0.36	15.0	10	0.8	2.1	Ø1.2	0.24x0.32	330
378-838-5	50x	0.40	12.0	4	0.7	1.7	Ø0.48	0.10x0.13	400
378-839-5	80x	0.55	10.0	2.5	0.5	0.9	Ø0.30	0.06x0.08	380

•The resolving power and focal depth of the discrete objective are values determined based on the reference wavelength.

Long working distance objectives for bright/dark fields

BD Plan Apo

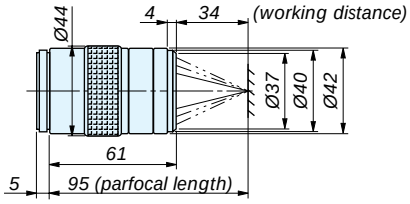
■ FEATURES

1. Long working distance objectives (BD Plan Apo 100x: 6mm) for both bright and dark field observations.
2. The special lenses and mirror in the optical tube make the ray of light fall obliquely on the specimen. Most ideal for observation of scratches and dents on the specimen surface.
3. The BD Plan Apo (Apochromat) is an excellent optical system, with the flat and chromatic aberration free image over the entire field of view.

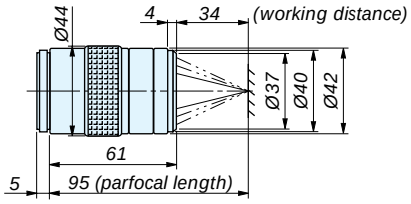
■ DIMENSIONS

*Mounting screws 26, thread 36 (see P.30.)

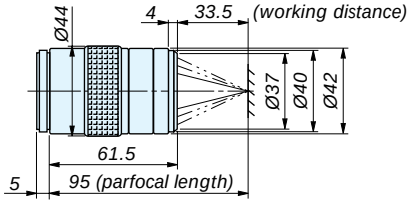
BD Plan Apo 2x : 378-831-4



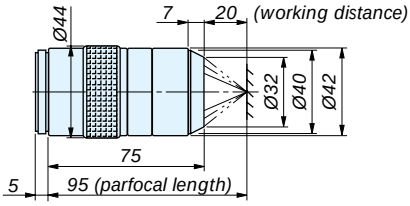
BD Plan Apo 5x : 378-832-4



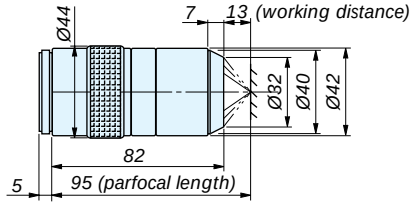
BD Plan Apo 10x : 378-833-4



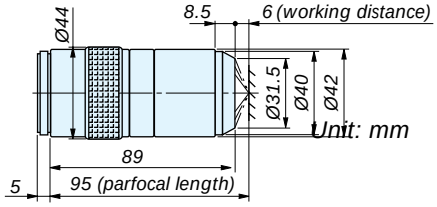
BD Plan Apo 20x : 378-834-4



BD Plan Apo 50x : 378-835-4



BD Plan Apo 100x : 378-836-5



Unit: mm

■ SPECIFICATIONS

Order No.	Magnification	N.A.	W.D. (mm)	S (mm)	R (μm)	DOF (μm)	Real FOV (mm) (Ø24 eyepiece)	Real FOV (VxH, mm) (1/2" CCD camera)	Mass (g)
378-831-4	2x	0.055	34.0	100	5.0	91	Ø12	2.4x3.2	230
378-832-4	5x	0.14	34.0	40	2.0	14.0	Ø4.8	0.96x1.28	240
378-833-4	10x	0.28	33.5	20	1.0	3.5	Ø2.4	0.48x0.64	240
378-834-4	20x	0.42	20.0	10	0.7	1.6	Ø1.2	0.24x0.32	300
378-835-4	50x	0.55	13.0	4	0.5	0.9	Ø0.48	0.10x0.13	320
378-836-5	100x	0.70	6.0	2	0.4	0.6	Ø0.24	0.05x0.06	320

•The resolving power and focal depth of the discrete objective are values determined based on the reference wavelength.

High-resolving power objectives for bright/dark fields

BD Plan Apo

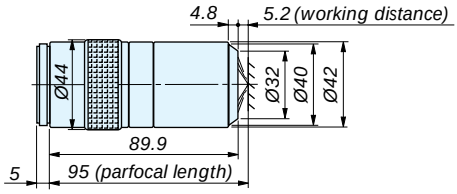
■ FEATURES

1. High resolving power objectives (BD Plan Apo 100x: N.A. 0.90) for both bright and dark field observations.
2. The special lenses and mirror in the optical tube make the ray of light fall obliquely on the specimen. Most ideal for observation of scratches and dents on the specimen surface.
3. The M Plan Apo (Apochromat) is an excellent optical system, with the flat and chromatic aberration free image over the entire field of view.

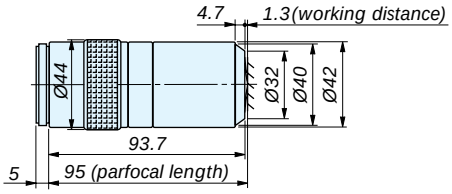
■ DIMENSIONS

*Mounting screws 40, thread 36 (see P.30.)

BD Plan Apo 50x : 378-845



BD Plan Apo 100x : 378-846



Unit: mm

■ SPECIFICATIONS

Order No.	Magnification	N.A.	W.D. (mm)	S (mm)	R (μm)	DOF (μm)	Real FOV (mm) (Ø24 eyepiece)	Real FOV (VxH, mm) (1/2" CCD camera)	Mass (g)
378-845*	50x	0.75	5.2	4	0.4	0.48	Ø0.48	0.10x0.13	420
378-846*	100x	0.90	1.3	2	0.3	0.24	Ø0.24	0.05x0.06	435

* Available on "made-to-order" basis.

•The resolving power and focal depth of the discrete objective are values determined based on the reference wavelength.

Super-long working distance objectives for bright/dark fields

BD Plan Apo SL

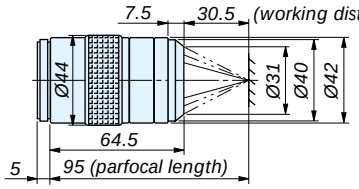
■ FEATURES

1. Super-long working distance (BD Plan Apo SL100x: 13mm) objectives for both bright and dark field observations.
2. The special lenses and mirror in the optical tube make the ray of light fall obliquely on the specimen. Most ideal for observation of scratches and dents on the specimen surface.
3. The M Plan Apo (Apochromat) is an excellent optical system, with the flat and chromatic aberration free image over the entire field of view.

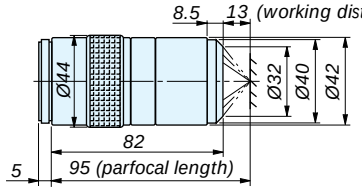
■ DIMENSIONS

*Mounting screws 40, thread 36 (see P.30.)

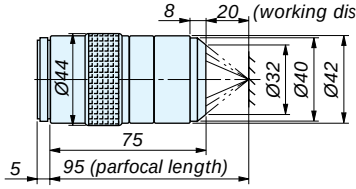
BD Plan Apo SL20x : 378-840-5



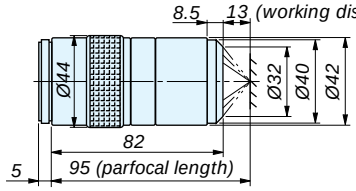
BD Plan Apo SL80x : 378-842-5



BD Plan Apo SL50x : 378-841-5



BD Plan Apo SL100x : 378-843-5



Unit: mm

■ SPECIFICATIONS

Order No.	Magnification	N.A.	W.D. (mm)	S (mm)	R (μm)	DOF (μm)	Real FOV (mm) (Ø24 eyepiece)	Real FOV (VxH, mm) (1/2" CCD camera)	Mass (g)
378-840-5	20x	0.28	30.5	10	1.0	3.5	Ø1.2	0.24x0.32	240
378-841-5	50x	0.42	20.5	4	0.7	1.6	Ø0.48	0.10x0.13	310
378-842-5	80x	0.50	15.0	2	0.6	1.1	Ø0.30	0.06x0.08	310
378-843-5	100x	0.55	13.0	2	0.5	0.9	Ø0.24	0.05x0.06	320

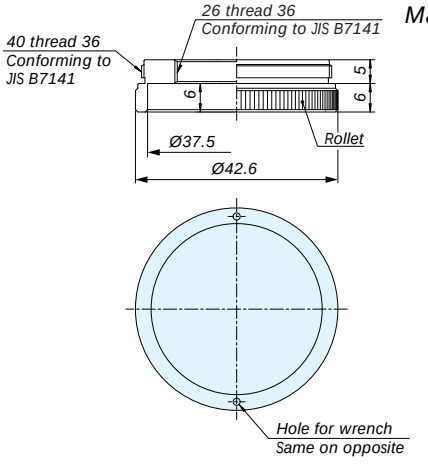
•The resolving power and focal depth of the discrete objective are values determined based on the reference wavelength.

Objective attachment adapter

This attachment adapter allows the bright-field objective to be attached to the bright/dark field switching revolver. The microscope assures parfocality even if the objective is used with a bright- and dark-field objective on the revolver.

■ DIMENSIONS

Mass: 14g



■ SPECIFICATIONS

Order No.	378-026-1
Compatible models	Microscope series equipped with a bright/dark field manual switching revolver or powered switching revolver. (FS300D/DT/D2/DT2, FS110/T series, MF-A/UA (THD type) series
Compatible objectives	M Plan Apo series, M Plan Apo SL series, G Plan Apo series

Standard objectives for finity correction system

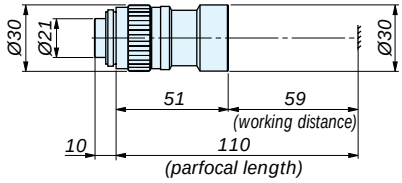
FEATURES

1. *Objectives for measuring applications. Employing the telecentric system (1x, 3x, 5x, and 10x lenses only) that minimizes lateral aberrations and prevents the image size from varying when the focus is lost.*
2. *Employing finity correction system.*
   (Distance between specimen and image: 280mm)
   (Distance between the lens mounting surface and the workpiece surface: 110mm)
3. *Long working distance (1x objective: 59mm) makes these lenses ideal for integration into a measuring system.*

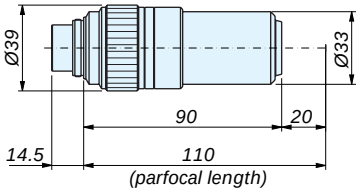
DIMENSIONS

**Mounting screws 26, thread 36 (see P.30.)*

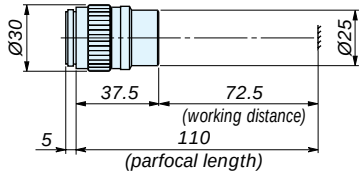
Objective 1x : 375-036



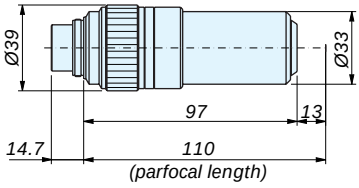
Objective 20x : 375-051



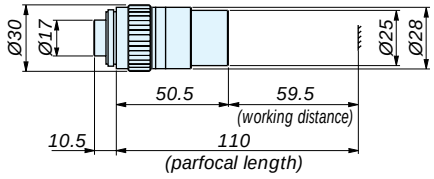
Objective 3x : 375-037



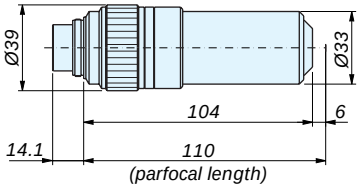
Objective 50x : 375-052



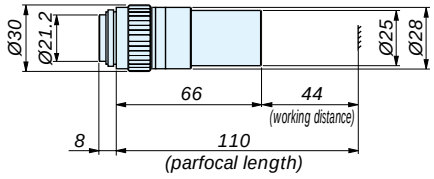
Objective 5x : 375-034



Objective 100x : 375-053



Objective 10x : 375-035



Unit: mm

SPECIFICATIONS

Order No.	Magnification	N.A.	W.D. (mm)	R (μm)	DOF (μm)	Real FOV (mm) (Ø24 eyepiece)	Real FOV (VxH, mm) (1/2" CCD camera)	Mass (g)
375-036	1x	0.03	59.0	9.2	306	Ø24	4.8x6.4	110
375-037	3x	0.07	72.5	3.9	56	Ø8	1.6x2.1	45
375-034	5x	0.11	59.5	2.5	23	Ø4.8	0.96x1.28	80
375-035	10x	0.18	44.0	1.5	8.0	Ø2.4	0.48x0.64	100
375-051	20x	0.42	20.0	0.7	1.6	Ø1.2	0.24x0.32	310
375-052	50x	0.55	13.0	0.5	0.9	Ø0.48	0.10x0.13	350
375-053	100x	0.70	6.0	0.4	0.6	Ø0.30	0.06x0.08	380

Compact objectives for finity correction system

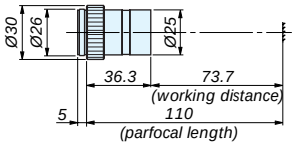
FEATURES

1. Objective lenses for general applications.
2. Super-long working distance (1x objective: 73.7mm), small and lightweight. Suitable for integration into a system.
3. The zoom type objective offers a wider range of applications.
4. Finity correction system. The distance between the workpiece and the image is 280mm.

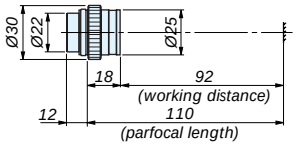
DIMENSIONS

*Mounting screws 26, thread 36 (see P.30.)

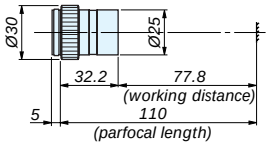
Objective 1x : 375-031



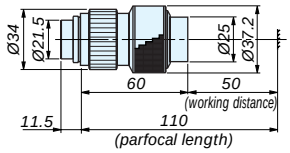
Objective 2x : 375-032



Objective 3x : 375-033



Zoom objective 1x~5x : 375-038



SPECIFICATIONS

Unit: mm

Order No.	Magnification		N.A.	W.D. (mm)	R (μm)	DOF (μm)	Real FOV (mm) (Ø24 eyepiece)	Real FOV (VxH, mm) (1/2" CCD camera)	Mass (g)
375-031	1x		0.03	73.7	9.2	306	Ø24	4.8x6.4	45
375-032	2x		0.06	92.0	4.6	76	Ø12	2.4x3.2	35
375-033	3x		0.07	59.5	2.5	23	Ø4.8	0.96x1.28	35
375-038	1x - 5x	1x	0.04	50.0	6.90	27	Ø24	4.8x6.4	200
		3x	0.10	50.0	2.75	27	Ø8	1.6x2.1	
		5x	0.10	50.0	2.75	27	Ø4.8	0.96x0.64	

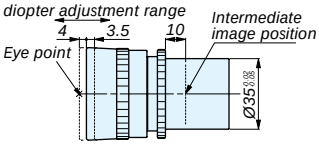
Wide field of view eyepieces

FEATURES

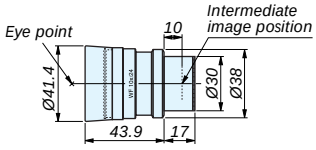
1. Wide field of view eyepieces (**375-031**: 24mm). An ultra-wide field type (UWF10X30), of which the field of view has been drastically widened, is also available.
2. The external focusing system makes the installation of reticle easy. Various types of reticle are available for the purpose to be used. However, note that the reticle cannot be attached to the (UWF10X30) type due to the internal focusing mechanism.

DIMENSIONS

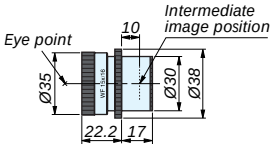
UWF 10x/30 : 378-851



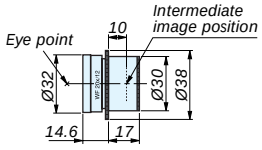
WF 10x/24 : 378-856



WF 15x/16 : 378-857



WF 20x/12 : 378-858



SPECIFICATIONS

Unit: mm

Order No.*	Magnification	Field number	Visibility adjustment	High eye point	Reticle	Mass (g)
378-851	10x	30	-8D to +4D	○	Not Available	250
378-856	10x	24	-8D to +5D	○	Available	45
378-857	15x	16	-8D to +5D	—	Available	35
378-858	20x	12	-8D to +5D	—	Available	35

* Sold as a set of 2 pieces.

RETICLES

FEATURES

1. A reticle can be inserted into the position of an intermediate image for simple measurement.
2. Reticle line widths 7μm (**516576**) and 10μm (others) to suit the microscopic size specimen.

DIMENSIONS

*Outside diameter Ø25mm, thickness 1mm

516848

90° full lines

516576

90°, 60° chain lines

516577

Concentric circles with crossing lines (P=Ø1.2/Ø1.2 - 18mm)

516578

Graduation line with crossing lines (P=0.1/20mm)

516849

Graduation line (P=0.1/10mm)

516850

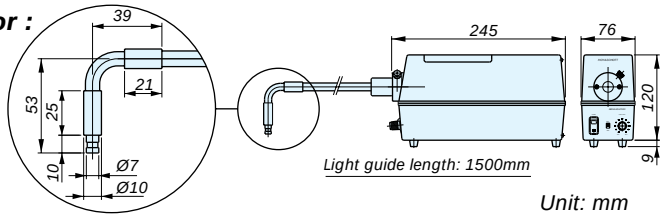
Graduation line (P=0.05/5mm)

516851

Grids (P=□1mm/□10mm)

ILLUMINATION SYSTEMS

Fiber illuminator : 378-700



Unit: mm

■ SPECIFICATIONS

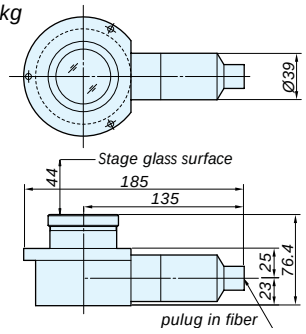
Light source		Halogen bulb (**517181**, 12V/100W, 100h service life)
Light guide		1500mm fiber cable (5mm dia.)
Brightness		Adjustable by volume
Optional filters	LB80	Color/temperature conversion filter (**12BAA584**)
	ND2	For 1/2 light volume (**12AAB251**)
	ND8	For 1/8 light volume (**12AAB252**)
	GIF	Green filter (**12BAA253**)

*See P.31 for the illustration of the fiber illuminator installed in a microscope unit.

Contour illumination : 176-736

This contour illumination unit is using for attaching the column stand (**378-730**). Fiber light source (**378-700**) is using.

Mass: 0.8kg

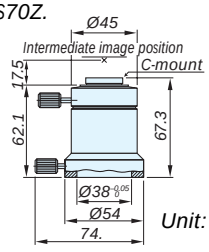


Unit: mm

TV CAMERA ADAPTER

Adapter B (378-042)

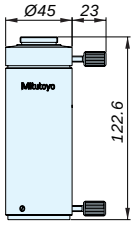
CCD camera adapter for the FS70Z.



Unit: mm

0.5x TV adapter (375-054)

With this adapter, the reduced (0.5x) workpiece image can be displayed on the TV monitor, allowing observation over a wide field of view. Use together with Adapter B.



Unit: mm

Polarizer

For polarized observation with the FS70 series.

For FS70Z : **378-092**

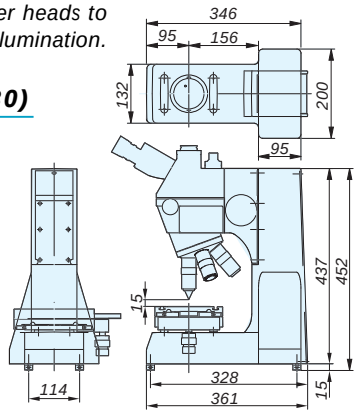
For FS70 and FS70L : **378-093**

For FS70L4 : **378-094**

STAND STAGE

For mounting the VMU, FS70, or VM-ZOOM microscope unit. Can be combined with a X-Y table and micrometer heads to work as a complete microscope reflective illumination.

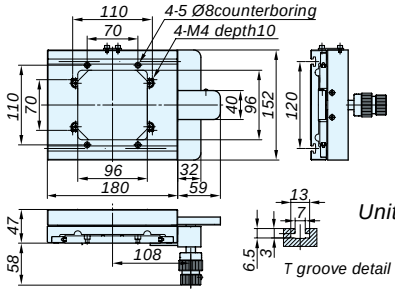
Stand (378-730)



Unit: mm

X-Y STAGE (378-020)

This X-Y stage is single axis drive X-Y stage for attaching the column stand.



Unit: mm

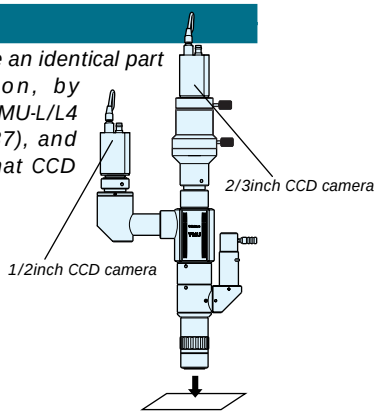
■ SPECIFICATIONS

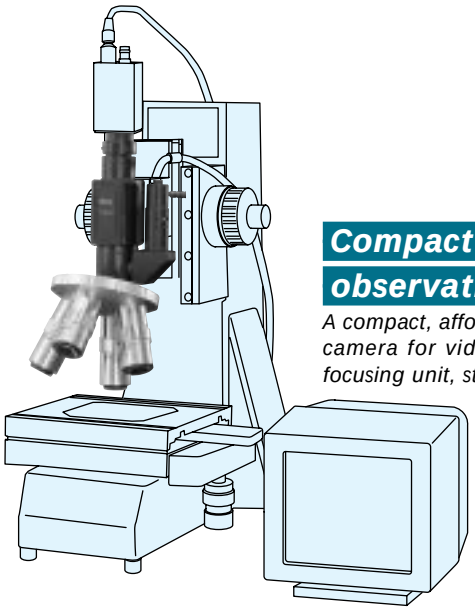
Travel range (X x Y axis)	50X50mm
Handle feed	34mm/ rotation

MICROSCOPE UNIT SYSTEM

Dual-magnification microscope equipped with a compact CCD camera

A microscope that can observe an identical part for different magnification, by combining a laser mount of VMU-L/L4 with camera mount (378-087), and installing two different format CCD cameras on each C-mount.



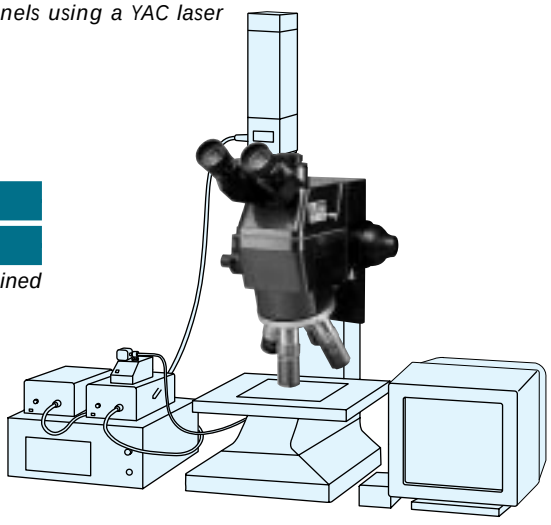


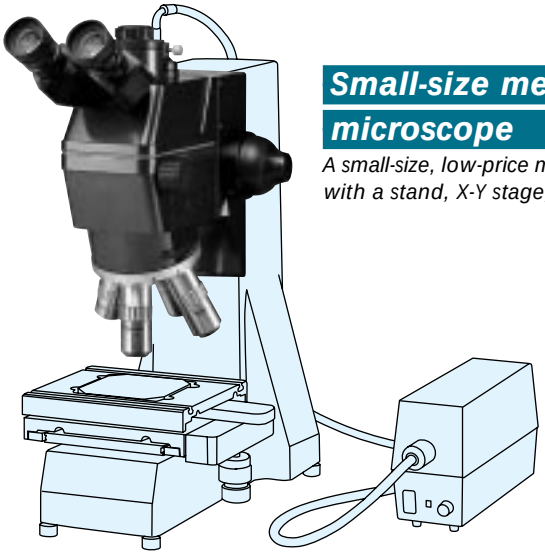
Compact video monitor observation microscope

A compact, affordable microscope equipped with a CCD camera for video monitoring in combination with a focusing unit, stand, X-Y stage, etc.

Incorporated into a laser irradiation system

This type is an optical unit for a system that aims at laser beam machining minutely thin films, such as IC wafers and LCD panels using a YAC laser oscillator.



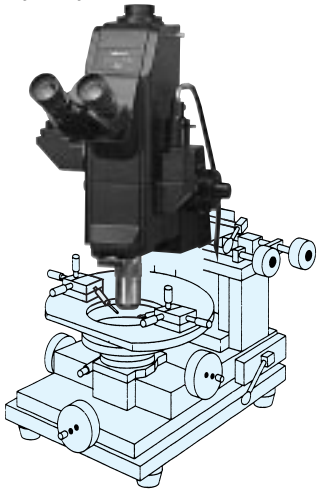


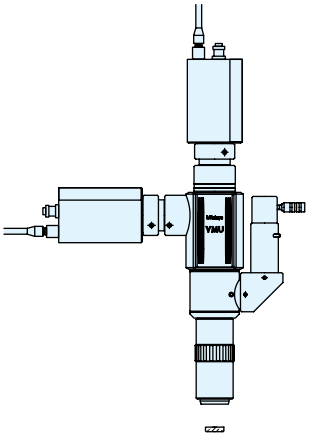
Small-size metallurgical microscope

A small-size, low-price metallurgical microscope combined with a stand, X-Y stage, etc.

Incorporated into an analysis evaluation system

Observation unit in the analysis system of the semi-conductor circuitry.





Dual compact CCD camera mounted microscope

A microscope unit that can be equipped with two compact-size CCD cameras (the image from the camera mounted horizontally becomes the mirror image).

Tube lens

■ FEATURES

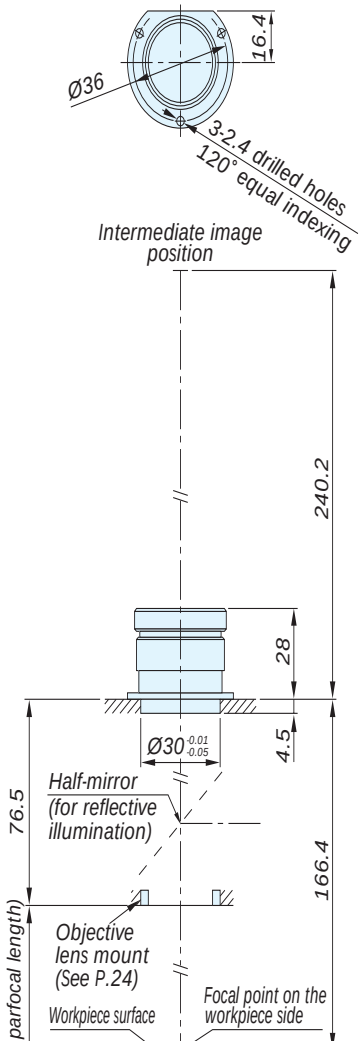
MT-1, 2, 40 : For use in the visible wavelength range. Aberration correction range: 435.8 – 656.3nm.

MT-L : Corrects aberration in ranges from the near-ultraviolet (355nm) to the visible (1064nm).

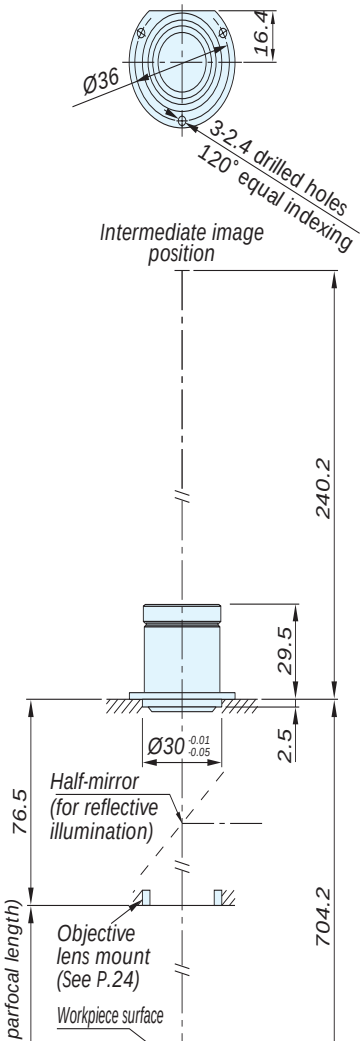
MT-L4 : Corrects aberration in ranges from the ultraviolet (266nm) to the visible (620nm).

■ DIMENSIONS

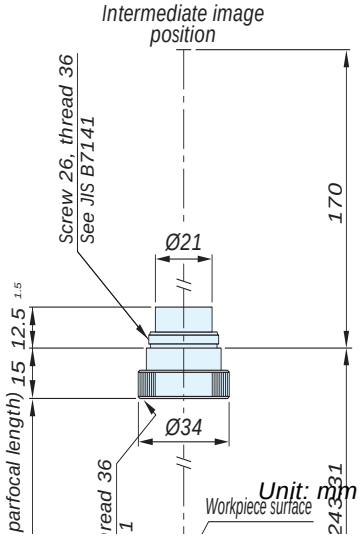
MT-1 : 970208



MT-2 : 970209



MT-40 : 378-010



Unit: mm

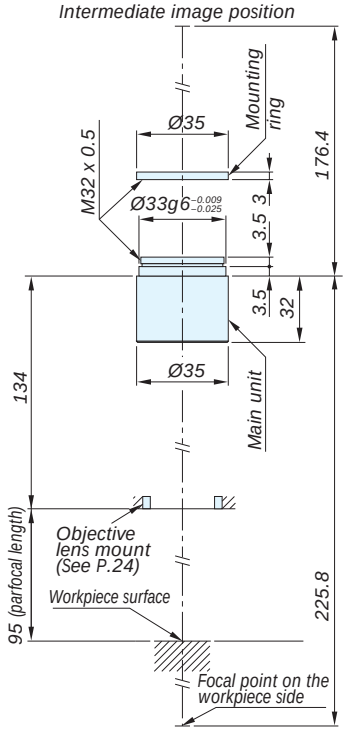
■ SPECIFICATIONS

Order No.	Focal length	Tube lens mag.	Image field (mm)	Incident lens dia. (mm)	Dimensions (mm)	Mass (g)
970208	200	1x	Ø30	Ø24	Ø40x32.5	43
970209	400	2x	Ø30	Ø18	Ø40x32.0	42
378-010	200	1x	Ø24	Ø11.2	Ø34x27.5	45

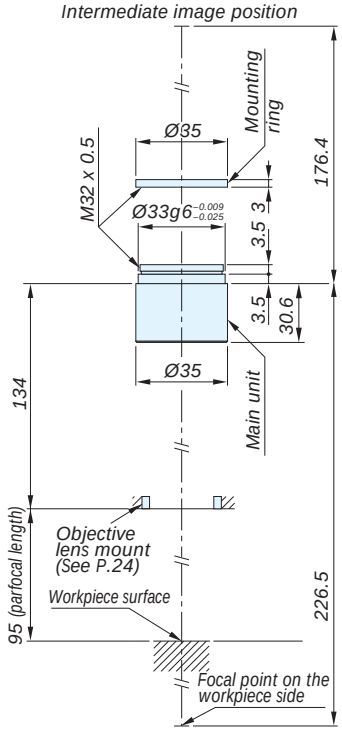
Note: A distance 76.5mm in the MT-1 and MT-2 drawings is for an image field of Ø30 (without shading). For an image field of Ø24 or Ø11 (the latter is the image field of a 2/3 inch CCD camera), use the formula on page 20 (1) and (2) to calculate the distance.

■ DIMENSIONS

MT-L : 378-008



MT-L4 : 378-009



Unit: mm

■ SPECIFICATIONS

Order No.	Focal length	Tube lens mag.	Image field (mm)	Incident lens dia. (mm)	Dimensions (mm)	Mass (g)
378-008	200	1x	Ø24	Ø22	Ø35x32.0	30
378-009	200	1x	Ø24	Ø23	Ø35x30.6	30

REFERENCE : PLACEMENT OF LENSES

The VMU, FS70, and VM-ZOOM series microscope units employ the infinity correction system, in which an objective and a tube lens form an image. This is a most ideal optical system for metallurgical microscopes. This system eliminates ghosts caused by a half mirror for reflective illumination and also eliminates image position shifts caused by prisms and filters. When designing your original microscope system using Mitutoyo's long working-distance objectives, use these tube lenses.

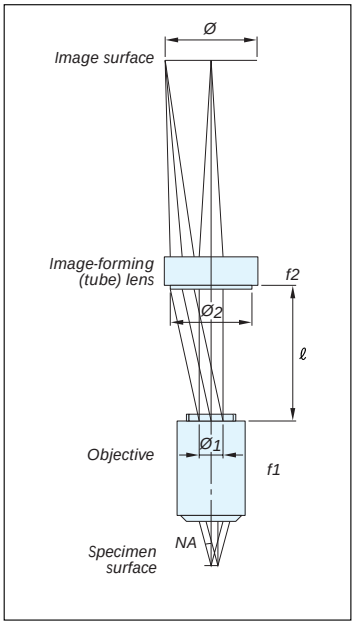
■ PLACEMENT OF OBJECTIVE AND TUBE LENS

Mitutoyo's long working-distance objective lenses are designed to cover a field of view of up to Ø30mm, when the tube lens MT-1 or MT-2 is placed at the specified distance from the objective. However, use the following formula to calculate the approximate distance, when a distance other than that as specified is required in order to insert your own optical system or other optical elements:

$\ell = (Ø_2 - Ø_1) \cdot f_2 / Ø$ (1)

$Ø_1 = 2 \cdot f \cdot N.A.$ (2)

$Ø_1$: Objective exit pupil diameter (mm)
$Ø_2$: Light incident lens (tube lens) diameter (mm)
f_2 : Focal length of tube lens
$Ø_1$: Image field



Example: *What is the distance (ℓ), when using M Plan Apo 10x and MT-1 to cover an image field of Ø24?*

From (2): $Ø_1$ = 2x20x0.28
= 11.2 (mm)

**From the M Plan Apo 10x specifications on P.9; focal length (f) = 20mm, numerical aperture (N.A.) = 0.28*

From (1): ℓ = (24-11.2)x200/24
= 106.6 (mm)

A distance up to ℓ = 106mm can cover an image field of Ø24 without shading.

** MT-1's incident lens diameter $Ø_2$ = 24mm, focal length f_2 = 200mm (See specifications on P.22.)*

A distance smaller than the specification does not affect an optical performance. Contact us for detailed information.

■ PLACEMENT OF OBJECTIVE AND TUBE LENS WITH USE OF LASER

When a masking is used in laser cutting, you can construct your original optical system using Mitutoyo's tube lenses for laser cutting. Determine the positions of the objective and the tube lens in the following manner:

- *Incident lens diameter of the tube lens has to be:*
  $Ø_2 > Ø + 2 \cdot f \cdot \tan\theta$
- *Assume that the width of the laser beam passing through the outermost side at distance L from the front focal point F of the condenser lens is A. This gives equation,*
  $A = Ø(L/f) + 2 \cdot f \cdot \tan\theta$, *At this position, if*
  $Ø_1 > A$, *laser-beam machining is possible without vignetting of the mask.*

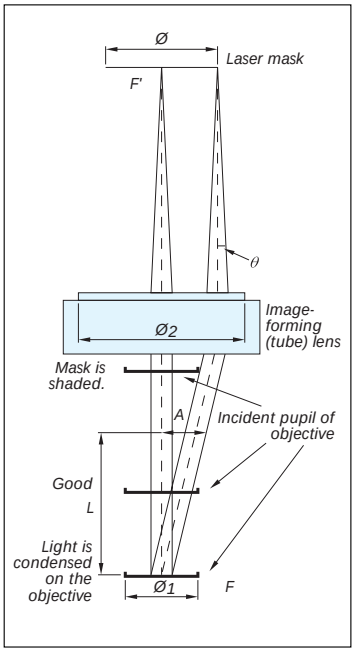
However, when the incident pupil of the objective approaches the front focal point F (L = 0), the laser beam is condensed at the objective to increase the laser energy density. This may cause damage to the objective. Therefore, it is recommended that the L value be set to 100mm or more for safety.

NOTE: The upper limit value of the laser energy density permissible for entry into the condenser lens alone is identical to that in the case where the laser beam is directly entered into the objective. If a new optical system is configured in combination with the objective with a condenser lens, exercise care so that the laser energy density at the objective position will not exceed the upper limit value of the laser inputted to the objective, since the entire laser beam is condensed by the condenser lens.

Example: *If an optical system is configured by separating a condenser lens with a focal length of 200mm from the objective by L = 100mm, the cross-sectional area of the laser beam at the incident position to the objective changes to approximately 1/4 (the density changes to 4 times as great). Therefore, the upper limit value of the energy density of the laser to be used must be reduced to 1/4.*

For YAG laser fundamental wave (wavelength: 1064nm, pulse width: 10ns)

0.2 (J/cm²) to 0.5 (J/cm²) - - - Upper limit value of used laser energy



Ø: Laser mask diameter
2θ: Diffusion angle of laser beam
$Ø_2$: Incident lens diameter of tube lens
f: Focal length of tube lens
$Ø_1$: Incident pupil diameter of objective

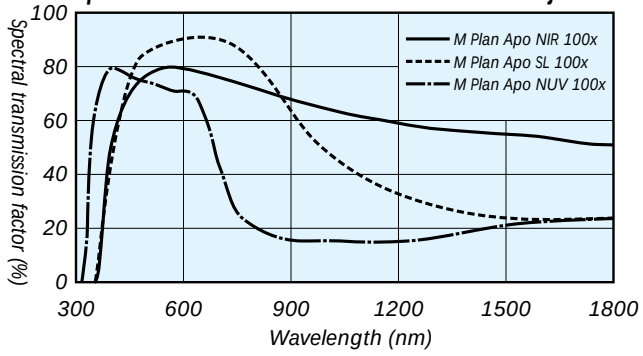
REFERENCE : OPTICAL CHARACTERISTICS OF OBJECTIVE

■ LIGHT TRANSMISSION

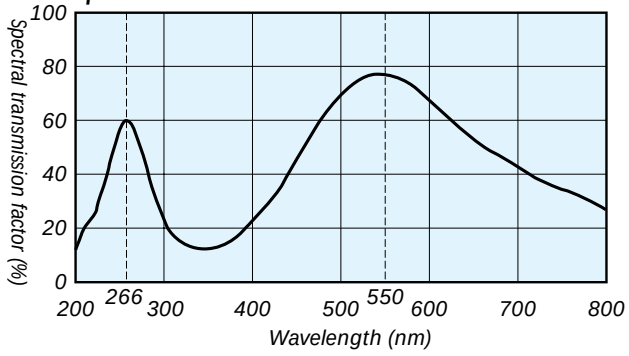
Mitutoyo's long working-distance objectives are grouped by wavelength ranges: near-infrared radiation range, visible range, near-ultraviolet radiation range, and ultraviolet radiation range. The M Plan Apo NIR series (for near-infrared radiation correction), M Plan Apo NUV series (for near-ultraviolet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

1. *Visible range: wavelength correction from 436nm to 656nm*
   The M Plan Apo series objectives are designed for fundamental waves of 587nm. All objectives in this series employ the highest-class plan apochromat with little chromatic aberration for various inspections.
2. *Near-infrared radiation range: wavelength correction from 480nm to 1800nm*
   The M Plan Apo NIR series objectives are designed for both inspection and laser cutting with an improved spectral transmission factor in the visible to near-infrared radiation ranges.
   These lenses allow cutting or trimming of semiconductor circuits, when combined with the YAG laser (wavelengths 1064nm or 532nm). They are designed to allow the workpiece image to be focused within the focal depth in the visible and near-infrared radiation ranges.
3. *Near-ultraviolet radiation range: wavelength correction from 355nm to 620nm*
   The M Plan Apo NUV series objectives are designed for both inspection and laser cutting with an improved spectral transmission factor in the visible to near-ultraviolet radiation ranges. These lenses can be used in the passivation of semiconductor circuit insulation films or in repairing LCD color filters. They are designed to allow the workpiece image to be focused within the focal depth in the visible and near-ultraviolet radiation ranges.
4. *Ultraviolet radiation range: 266nm & 550nm wavelength correction*
   The M Plan UV series objectives are designed for both inspections and laser cutting that involve ultraviolet radiation. Designed to improve the spectral transmission factor in the ultraviolet range (wavelength 266nm) and the visible range (center wavelength 550nm).
   When used with the YAG laser (wavelength 266nm or 532nm), these lenses will improve performance and efficiency of the process.

Spectral transmission characteristics of 100x objective



Spectral transmission characteristics of M Plan UV 80x



■ CAUTIONS IN USING THE YAG LASER

Since laser cutting with microscopes is meant for cutting microscopic fine films used in semiconductors and liquid crystals, objectives are not designed to transmit a high-power laser beam. Therefore, when using the YAG laser, determine the level of laser output as follows:

YAG laser wavelength	Beam energy density (output)	Pulse width	Applicable objective
1064nm	0.2J/cm²	10ns	M Plan Apo NIR
532nm	0.1J/cm²	10ns	M Plan Apo NUV
355nm	0.05J/cm²	10ns	
266nm	0.04J/cm²	10ns	M Plan UV

When the pulse width is shorter, multiply beam energy density by the aqware root of the ratio to 10ns.
(Example) When pulse width of 1064nm YAG laser is 1/4, beam energy density is approximately lowered by 1/2 (= 0.1J/cm²).

Note) In order to prevent any unexpected damage to the equipment, consult your nearest Mitutoyo office for precautions before transmitting various laser beams through a microscope or objective.

DESCRIPTION : LASER USAGE AND PRECAUTIONS

Mitutoyo microscope units, VMU, FS70, and VM-ZOOM series include types that can perform laser beam machining using a built-in type laser for microscopes, such as the Nd: YAG laser fundamental generation (1064nm), second harmonic generation (532nm), third harmonic generation (355nm), and fourth harmonic generation (266nm). The laser-compatible microscope unit and microscope objective are intended for microscopic laser beam machining and therefore must not emit high-output laser energy. Be sure to confirm the precautions for use of the laser beforehand.

■ LASER INPUT CONDITION OF A LASER-COMPATIBLE MICROSCOPE UNIT

Determine the upper limit value of an input laser under the following conditions. The laser beam incident to the optical system is assumed to have parallel rays.

VMU series

	VMU-L			VMU-L4	
Wave length of laser to be used (nm)	1064	532	355	532	266
Pulse laser Upper limit value of input laser (J/cm²) Pulse width (10ns)	0.095	0.075	0.025	0.080	0.015
Continuous oscillaying laser (CW) Upper limit value of input laser (kW/cm²)	0.23	0.18	0.07	0.2	0.05

FS70 series

	FS70L			FS70L4	
Wave length of laser to be used (nm)	1064	532	355	532	266
Pulse laser Upper limit value of input laser (J/cm²) Pulse width (10ns)	0.082	0.041	0.018	0.075	0.015
Continuous oscillaying laser (CW) Upper limit value of input laser (kW/cm²)	0.21	0.10	0.06	0.2	0.05

VM-ZOOMseries

	VMZ40M-L/BL/VMZ40R-L/BL			VMZ40R-L4/BL4	
Wave length of laser to be used (nm)	1064	532	355	352	266
Pulse laser Upper limit value of input laser (J/cm²) Pulse width (10ns)	0.1	0.06	0.03	0.075	0.015
Continuous oscillaying laser (CW) Upper limit value of input laser (kW/cm²)	0.25	0.15	0.1	0.2	0.05

■ UPPER LIMIT VALUE OF THE LASER INPUTTED TO THE OBJECTIVE

If the laser is to be used by entering it directly into the objective, determine the upper limit value of the input laser under the following conditions.

	M Plan Apo NIR series	M Plan Apo NIR series M Plan Apo NUV series M Plan Apo NIR series	M Plan Apo NUV series	M Plan UV series
Wave length of laser to be used (nm)	1064	532	355	266
Pulse laser Upper limit value of input laser (J/cm²) Pulse width (10ns)	0.2	0.1	0.05	0.04
Continuous oscillaying laser (CW) Upper limit value of input laser (kW/cm²)	0.5	0.25	0.16	0.12

NOTE: If the pulse width of the laser is to be shortened, reduce the emission energy density by the square root of the pulse width ratio.

Example: When shortening the pulse width to 1/4, reduce the energy density to approximately 1/2. If the laser with a pulse width of 2.5ns and a wavelength of 1064nm is used, the upper limit value of the input laser becomes 0.1 (J/cm²).

■ *PRECAUTIONS FOR USE OF THE LASER*

1. Difference in beam system:

The laser increases its energy density as the laser beam converges. The energy density increases approximately proportionally to the area ratio of a beam system. If configuring an optical system by yourself, exercise care so that the laser does not converge inside the optical system.

2. Difference in wavelength:

The upper limit value of the input laser in the optical system differs depending on the laser wavelength. The laser photon energy increases as the wavelength shortens. Note that the laser photon energy is inversely proportional to the wavelength.

Example: Refer to the section that describes the case where the laser is entered directly into the objective.
If the wavelength decreases to 1/2, the photon energy increases by 2 times. Therefore, the upper limit value of the energy density of the laser to be entered in the optical system must be reduced to 1/2.

3. Difference in pulse width:

If the pulse width is narrowed, the electric field increases by the square root of the reciprocal of the pulse width ratio. For example, if the pulse width becomes 1/4, the electric field will be twice as large. Note that this is identical to the case where the threshold decreases by that ratio.

Example: If a laser with a pulse width of 2.5ns and a wavelength of 1064nm is entered into the objective, the upper limit value of the laser energy density must be 0.1 (J/cm^2).

4. Dirt on the lens surface:

If optical elements in the laser path, such as the lens surface, are soiled with dust and dirt, the lens and other elements maybe damaged by the laser beam. Care should be exercised.

5. Precautions on use:

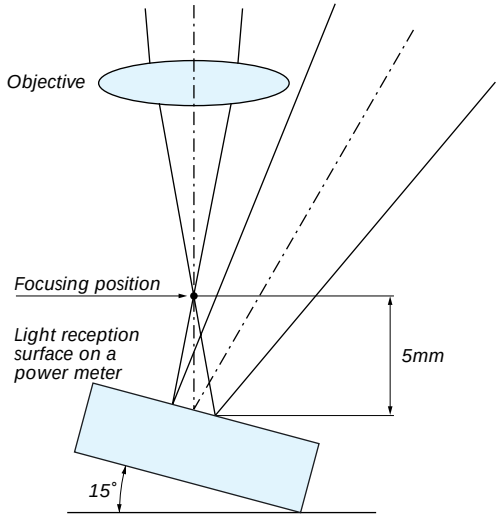
If the reflected beam of the laser emitted from the objective is returned to the optical system, the laser beam will converge in the system, resulting in damage to the lens and optical elements (including the mirror and prism). Exercise care so as not to return the reflected laser beam to the optical system.

Example: To measure the emission energy of the laser-beam machining optical system or to measure the emission factor, a power meter placed behind the laser converging position of the laser beam. In this case the laser beam reflected from the power meter will return and converge into the optical system. This may cause laser damage to the optical system. If such a measurement is to be made, take the following measures, for example.

•Power meter location: Defocused position 5mm below the beam focused position

•Power meter tilt angle: 15° from its orientation perpendicular to the laser beam

If the power meter is oriented as in the figure at the right, the reflected beam will not return directly into the optical system. This prevents the system from being damaged by the returned laser beam.

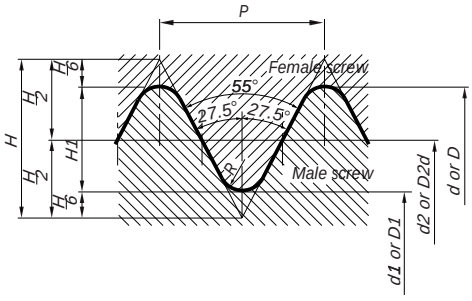


REFERENCE : MOUNTING SCREW STANDARDS

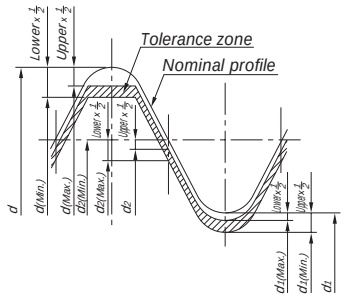
Objective

1. Applicable range: For Mitutoyo microscope objectives.
2. Contours and dimensions in accordance with JIS B-7141-1994

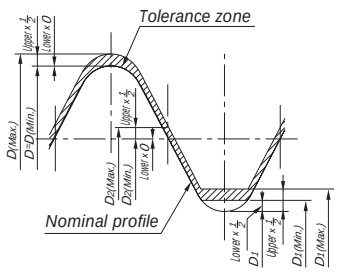
Nominal profile



Male screw



Female screw



For objectives for bright field and objectives for finity correction system

Nominal sizes

Ø	n	P	R	Male/Female screw		
				O.D./R.D.	P.D./P.D.	R.D./I.D.
26	36	0.706	0.097	26.000	25.548	25.096

Limit of size and tolerance Unit: mm

		Male screw			Female screw		
		O.D.	P.D	R.D.	R.D.	P.D.	I.D.
Limit of size	Max.	25.896	25.502	25.050	26.076	25.624	25.230
	Min.	25.820	25.426	24.974	26.000	25.548	25.154
Tolerance	U	-0.104	-0.046	-0.046	+0.076	+0.076	+0.134
	L	-0.180	-0.122	-0.122	+0.000	+0.000	+0.058

For objectives for bright field/dark field

Nominal sizes

Ø	n	P	R	Male/Female screw		
				O.D./R.D.	P.D./P.D.	R.D./I.D.
40	36	0.706	0.097	40.00	39.548	39.096

Ø: Diameter (mm)
n: Number of thread per 25.4mm
P: Pitch (mm)
R: Roundness of crest and root

O.D.: Outer diameter (mm)
R.D.: Root diameter (mm)
P.D.: Pitch diameter (mm)
I.D.: Inner diameter (mm)

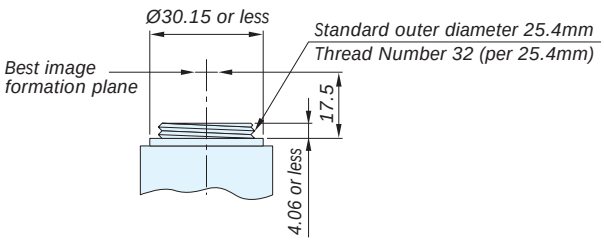
Limit of size and tolerance Unit: mm

		Male screw			Female screw		
		O.D.	P.D	R.D.	R.D.	P.D.	I.D.
Limit of size	Max.	39.896	39.502	39.050	40.076	39.624	39.230
	Min.	39.820	39.426	38.974	40.000	39.548	39.154
Tolerance	U	-0.104	-0.046	-0.046	+0.076	+0.076	+0.134
	L	-0.180	-0.122	-0.122	+0.000	+0.000	+0.058

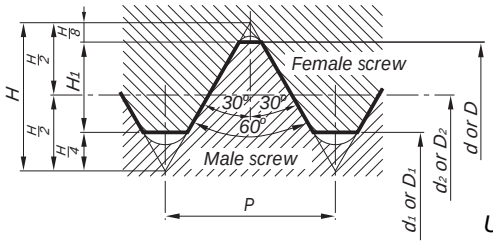
C-MOUNT

1. Mount contour for 2/3" and 1/2" CCD Camera is the same as mount contour for 8mm and 16mm movie camera lenses.
2. Screw contour is in accordance with JIS B0208.

Mounting screw and flange focal length



Nominal profile



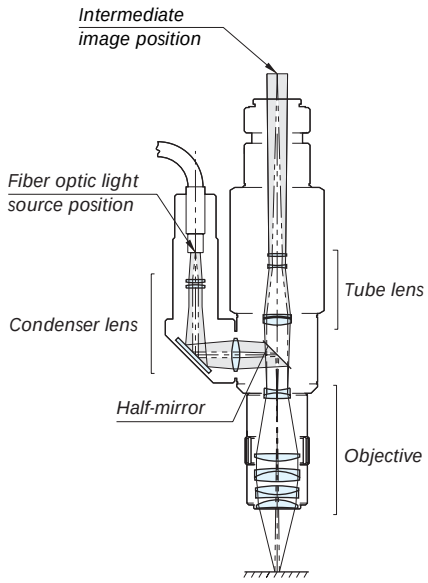
Unit: mm

Unit: mm

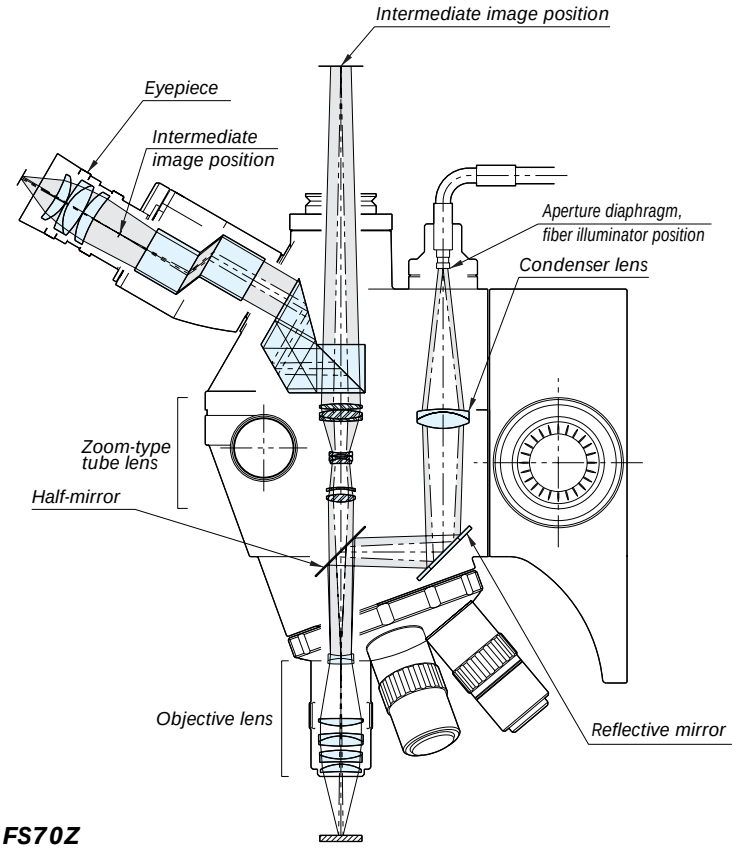
	Ø	n	Pitch	Male screw			Female screw		
				O.D.	P.D	R.D.	R.D.	P.D.	I.D.
Nominal size	25.4	32	0.794	25.400	24.884	24.541	25.400	24.884	24.541
Tolerance	—	—	—	-0.029	-0.027	-0.142	Not specified	+0.124	+0.199
	—	—	—	-0.180	-0.124	Not specified	Not specified	+0.000	-0.004

OPTICAL SYSTEMS OF MICROSCOPE UNITS

Mitutoyo's microscopes employ the infinity correction system whose magnification is arbitrary and is determined by the combination of objective and tube lens, to allow clear images with little chromatic aberration. The optical systems of the two models that best represent Mitutoyo's various microscope units are shown below, as references. Refer to these when designing your original microscope optical system by inserting an optical element such as prism, half-mirror, etc., between the objective and the tube lens, where the light incident on the specimen is parallel to the optical axis.



VMU-V *(model with Telecentric illumination unit with aperture diaphragm)*



FS70Z

1) The light beam emitted from the tip of the fiber is first diffused by the illumination system, reflected by the half-mirror, then forms its image of Ø11.2mm at the position of the exit pupil (approximately 5mm below the objective mounting surface). Subsequently, the light is transmitted through the objective, then illuminates the specimen.*
2) The light reflected on the specimen is transmitted back through the objective and the half-mirror, then it is made to form the image of the specimen at the intermediate image position, by the tube lens.

**The M Plan Apo 5x and 10x objectives have the largest exit pupil diameter. Contact Mitutoyo for inquiries concerning these lenses.*

1) The light beam emitted from the tip of the fiber is first diffused by the condenser lens, reflected by the reflective mirror and the half-mirror, then forms its image of Ø11.2mm at the position of the exit pupil. Subsequently, the light is transmitted through the objective, then illuminates the specimen.
2) The light reflected on the specimen is transmitted back through the objective and the half-mirror, then it is made to form the image of the specimen by the zoom lens, at the two intermediate image positions shown above.

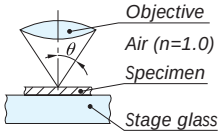
GLOSSARY

1. N.A. : Numerical Aperture

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

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

n is an index of refraction made by the medium between an objective and a specimen. n=1.0 for air.
θ is an angle made by the ray of light that goes through one end of an objective and an optical axis.



2. R : Resolving Power

Minimum space distinguishable between points or lines. Resolving power is determined by N.A. and wavelength λ.

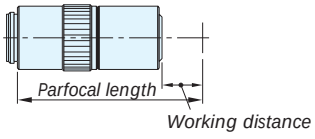
$$R\ (\mu m) = \frac{\lambda}{2 \cdot N.A.} \quad \lambda = 0.55\mu m \text{ (Standard wavelength)}$$

3. W.D. : Working distance

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

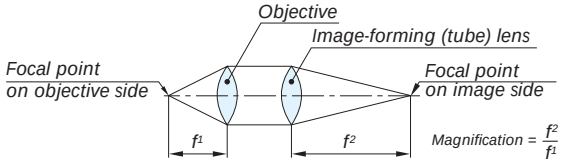
4. Parfocal Length

Distance between the surface of the specimen and the objective mounting position when in focus.



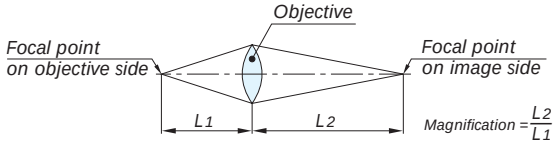
5. Infinity correction system

An optical system in which the image is formed by an objective and a tube lens.



6. Finity correction system

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



7. F : Focal Length

Distance between a principal point and a focal point. f^1 is a focal length of objective, f^2 is a focal length of tube lens. Magnification is determined by the ratio of objective focal length and tube lens focal length. (For infinity correction system)

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

(Ex.) $1x = \frac{200\ (mm)}{200\ (mm)}$ (Ex.) $10x = \frac{200\ (mm)}{20\ (mm)}$

8. Real field of view

(1) Range (diameter) of specimen observable with a microscope.

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

**Field number of eyepiece is 24 (mm)*

(Ex.) Real field of view for 1x objective is $\frac{24\ (mm)}{1} = 24\ (mm)$

Real field of view for 10x objective is $\frac{24\ (mm)}{10} = 2.4\ (mm)$

(2) Range of specimen observable on TV monitor

$$\text{Real field of view (mm)} = \frac{\text{Size of CCD Camera image element}}{\text{Magnification of objective}}$$

**Size of 1/2" CCD image element is 4.8 x 6.4 (mm)*
(Ex.) Real field of view for 1x objective is 4.8 x 6.4 (mm)
Real field of view for 10x objective is 0.48 x 0.64 (mm)

9. D.F. : Depth of focus

Range around the focal point in which the image is still clear. The larger the N.A., the smaller the focal depth.

$$D.F.\ (\mu m) = \frac{\lambda}{2 \cdot (N.A.)^2} \quad \lambda = 0.55\mu m \text{ (Standard wavelength)}$$

(Ex.) N.A. of M Plan Apo 100x is 0.7

Focal depth in this case is $\frac{0.55\ (\mu m)}{2 \times 0.72} = 0.6\ (\mu m)$

10. Bright field illumination and dark field illumination

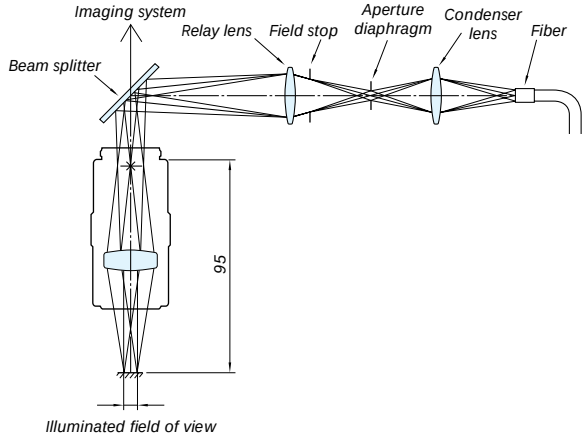
In bright field illumination the ray of light incident upon the object goes through the objective (the ray of light incident upon the object is parallel to the optical axis). In the dark field illumination, the ray of light does not go through the objective (the ray of light incident upon the object is at an angle from the optical axis); therefore, scratches and dents on the specimen surface are illuminated while the other, intact part remains dark.

11. Apochromatic objective and achromatic objective

Apochromatic objective is chromatic aberration corrected for red, blue, and yellow.
Achromatic objective is chromatic aberration corrected for red and yellow only.

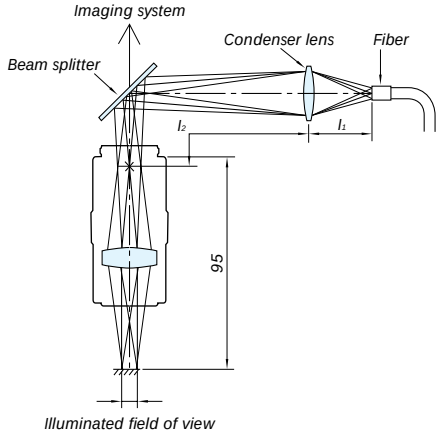
12. Koehler illumination

Distance between a principal point and a focal point. f^1 is a focal length of objective, f^2 is a focal length of tube lens. Magnification is determined by the ratio of objective focal length and tube lens focal length. (For infinity correction system)



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 light passing range and is also related to the brightness and resolving power of an optical system. This diaphragm is especially suitable for use 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 light outside the observation range. Sharp and clear images are secured by cutting off the redundant light.

16. Plan

Denotes a lens that is compensated so that a flat image is correctly projected as a plane, by correcting the spherical aberration/curvature of the field of an achromatic lens or an apochromatic lens. All Mitutoyo FS series objectives use plan apochromats.

17. Vignetting

Denotes a phenomenon in which the circumference of an image is partially eclipsed or shaded due to some disturbance in the process of imaging optical information (projected image) entered through an objective (or a projection lens) with an eyepiece (or on a projection screen).

18. Flare

Denotes an unnecessary (redundant) beam of light that is not used for imaging. It causes a phenomenon in which the light is spread over the visual field (appears white). This is due to light dispersion and reflection inside lenses or the optical tube.

19. Double image

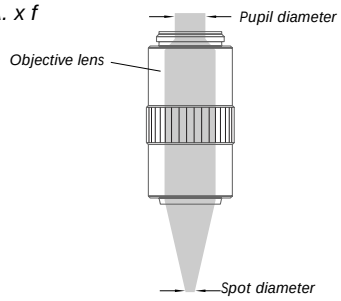
Denotes a phenomenon in which an image looks as if it is a double image due to redundant light projection and optical part interference in the optical system for imaging.

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 be entered into an objective from the rear side. The pupil diameter of a light flux is calculated according to the following expression.

$$(Ømm) = 2 \times N.A. \times f$$



• Spot diameter

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

$$(Ø\mu m) = 1.22 \times \frac{\lambda}{N.A.}$$

However, the above expression cannot be applied if the light source uses 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.

$$(Ø\mu m) = \frac{4 \times \lambda \times 1}{\pi \times D}$$

Microscope FS300 Series

The most ideal microscope unit that makes inspection of 300mm IC wafer exteriors easier. In addition to the popular long working distance objectives, the body of this microscope is constructed as one piece, in which both high-rigidity and high resistance against vibration are combined, using a constructional analysis engineering technology.

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"EMISSION MICROSCOPE", Analytical System with Long Working Distance Objective for Semiconductors

The Emission Microscope is an analytical system for semiconductors. It can locate an abnormality inside a semiconductor device by detecting extremely faint light ranging from visible ray to near-infrared ray.

Inspecting the back side of IC wafer

Photograph provided by Hamamatsu Photonics

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Mitutoyo Scandinavia AB
Släntv. 6 • Box 712
SE-194 27 Upplands Väsby
Tel: 08-594 109 50 • Fax: 08-590 924 10
info@mitutoyo.se • www.mitutoyo.se

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