FOREWORD

To obtain the highest performance and the longest service life from your objective, carefully read this manual thoroughly prior to setup and operation.
After reading this manual keep it near the objective for quick reference.

HANDLING PRECAUTIONS

To ensure the best performance and safety of this precise objective, handle it so as to satisfy the following conditions.

Important

Avoiding bump: Handle the objective carefully so that no part is subjected to any impact or excessive force.
Caution when carrying the objective: Carefully hold the objective.
Installation: Choose the place where the objective will not be subjected to direct sunlight, dirt, dust, high temperature, high humidity, or vibration.

Be sure not to fall or drop the objective.

Otherwise, the performance of the objective must be adversely affected.

Do not disassemble the objective.

The objective consists of precise components and has been strictly adjusted. If the product is disassembled by the user, its performance cannot be guaranteed even within the warranty period.

When using a laser unit , observe the following safety points.

WARNING

- Blindness can result if the laser light contacts the naked eye. Never look at the laser light directly.
  Caution is required since the UV (266 nm),NUV(355nm) and NIR(1064nm) laser are invisible.
- When the laser unit is operating, always wear protective goggles designed for lasers.
- Laser light reflected or scattered from processed workpiece is also dangerous. Do not look at processed workpiece directly when the laser is operating. Install an appropriate shield around processed workpiece.

WARRANTY

In the event that the product should prove defective in workmanship or material within one year from the date of original purchase for use, it will be repaired or replaced, at our option, free of charge upon its prepaid return to us.
If the product fails or is damaged for any of the following reasons, it will be subject to a repair charge, even if it is still under warranty.

1 Failure or damage owing to inappropriate handling or unauthorized modification or repair.
2 Failure or damage owing to transport or dropping of the product after purchase.
3 Failure or damage owing to fire, salt, gas, abnormal voltage, or natural disaster.

This warranty is effective only where the instrument is properly installed and operated in conformance with the instructions in this manual.

Export Control Compliance

This Product falls into the Catch-All-Controlled Goods or Program under the Category 16 of the Separate Table 1 of the Export Trade Control Order or the Category 16 of the Separate Table of the Foreign Exchange Control Order, based on the Foreign Exchange and Foreign Trade Law of Japan.
Further, this User's Manual also falls into the Catch-All-Controlled Technology for use of the Catch-All-Controlled Goods under the Category 16 of the Separate Table of the Foreign Exchange Control Order.
If you intend re-exporting or re-providing the product or technology to any party other than yourself, please consult with Mitutoyo prior to such re-exporting or re-providing.

1. OVERVIEW

- A specimen with steps that cannot be focused on with the conventional short workingdistance objectives, can be easily observed with the use of Mitutoyo long workingdistance objectives (e.g. 200x objective: 13mm).
- The M/BD 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.

2. SPECIFICATION

2.1 Corrected wavelength range

(1) Visible range: wavelength correction from 436nm to 656nm

The M/BD/G Plan Apo (SL) 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/LCD 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/LCD 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.

Important

- NIR series supports near IR (1064 nm) and visible (532 nm) wavelengths. NUV series supports near UV (355nm) and visible (532 nm) wavelengths. UV series supports UV (266 nm) and visible (532 nm) wavelengths. Do not use any other wavelengths.
- Do not use laser other than NIR , NUV and UV series.

2.2 Model list

Series	Model	Numerical aperture N.A.	Working distance W.D.[mm]	Focal length f [mm]	*1 Resolving power R [μm]	*1 Depth of focus ±D.F.[μm]	Wavelength correction [nm]
M Plan Apo Series	M Plan Apo 1× *2*7	0.025	11.0	200	11.0	440	436~656
	M Plan Apo 2× *6*7	0.055	34.0	100	5.0	91	
	M Plan Apo 5×	0.14	34.0	40	2.0	14	
	M Plan Apo 10×	0.28	34.0	20	1.0	3.5	
	M Plan Apo 20×	0.42	20.0	10	0.7	1.6	
	M Plan Apo 50×	0.55	13.0	4	0.5	0.9	
	M Plan Apo 100×	0.70	6.0	2	0.4	0.6	
	M Plan Apo HR 10× *3	0.42	15.0	20	0.6	1.55	
	M Plan Apo HR 50×	0.75	5.2	4	0.4	0.48	
	M Plan Apo HR 100×	0.90	1.3	2	0.3	0.34	
M Plan Apo SL Series	M Plan Apo SL20×	0.28	30.5	10	1.0	3.5	
	M Plan Apo SL50×	0.42	20.5	4	0.7	1.6	
	M Plan Apo SL80×	0.50	15.0	2.5	0.6	1.1	
	M Plan Apo SL100×	0.55	13.0	2	0.5	0.9	
	M Plan Apo SL200×	0.62	13.0	1	0.4	0.7	
G Plan Apo Series	G Plan Apo 20×	0.28	29.42(in air)	10	1.0	3.5	
	G Plan Apo 50×	0.50	13.89(in air)	4	0.6	1.1	
*4 M Plan Apo NIR Series	M Plan Apo NIR 5×	0.14	37.5	40	2.0	14.0	480~1800
	M Plan Apo NIR 10×	0.26	30.5	20	1.1	4.1	
	M Plan Apo NIR 20×	0.40	20.0	10	0.7	1.7	
	M Plan Apo NIR 50×	0.42	17.0	4	0.7	1.6	
	M Plan Apo NIR 100×	0.50	12.0	2	0.6	1.1	
	M Plan Apo NIR-HR 50×	0.65	10.0	4	0.42	0.65	
	M Plan Apo NIR-HR 100×	0.70	10.0	2	0.39	0.56	
*4 LCD Plan Apo NIR Series	LCD Plan Apo NIR 20×(t1.1)	0.40	19.98(in air)	10	0.7	1.7	
	LCD Plan Apo NIR 50×(t1.1)	0.42	17.13(in air)	3.9	0.7	1.6	
	LCD Plan Apo NIR 50×(t0.7)	0.42	17.26(in air)	3.9	0.7	1.6	
	LCD Plan Apo NIR 100×(t0.7)	0.50	12.11(in air)	2	0.6	1.1	
M Plan Apo NUV Series	M Plan Apo NUV 20×	0.40	17.0	10	0.7	1.7	355~620
	M Plan Apo NUV 50×	0.42	15.0	4	0.7	1.6	
	M Plan Apo NUV 100×	0.50	11.0	2	0.6	1.1	
LCD Plan Apo NUV Series	LCD Plan Apo NUV 50×(t0.7)	0.42	14.76(in air)	4	0.7	1.6	
	LCD Plan Apo NUV 50×(t1.1)	0.42	14.75(in air)	4	0.7	1.6	
*5 M Plan UV Series	M Plan UV 20×	0.36	15.0	f_{266}=10 f_{550}=10.4	0.8	2.1	266 & 550
	M Plan UV 50×	0.40	12.0	f_{266}=4 f_{550}=4.5	0.7	1.7	
	M Plan UV 80×	0.55	10.0	f_{266}=2.5 f_{550}=2.9	0.5	0.9	
BD Plan Apo Series	BD Plan Apo 2× *6*7	0.055	34.0	100	5.0	91	436~656
	BD Plan Apo 5×	0.14	34.0	40	2.0	14.0	
	BD Plan Apo 10×	0.28	34.0	20	1.0	3.5	
	BD Plan Apo 20×	0.42	20.0	10	0.7	1.6	
	BD Plan Apo 50×	0.55	13.0	4	0.5	0.9	
	BD Plan Apo 100×	0.70	6.0	2	0.4	0.6	
	BD Plan Apo HR 50×	0.75	5.2	4	0.4	0.48	
	BD Plan Apo HR 100×	0.90	1.3	2	0.3	0.24	
BD Plan Apo SL Series	BD Plan Apo SL20×	0.28	30.5	10	1.0	3.5	
	BD Plan Apo SL50×	0.42	20.0	4	0.7	1.6	
	BD Plan Apo SL80×	0.50	13.0	2	0.6	1.1	
	BD Plan Apo SL100×	0.55	13.0	2	0.5	0.9	

*1 The resolving power and focal depth of the discrete objective are values determined based on the reference wavelength (λ=550nm).

*2 Mount the objective on a microscope with an ocular tube and an eyepiece of the field number 24. If the objective is used with an ocular tube and an eyepiece of the field number 30, a ring-like eclipse appears in the periphery of the field of view.

*3 The pupil diameter of this HR 10x objective is 16.8mm (The maximum pupil diameter at M Plan Apo objective series is 11.2mm.), therefore note that when this objective is mounted on some microscopes, the N.A. of 0.42 may not be achieved.

*4 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.

*5 When a microscope and a YAG laser are used together and the mask is projected onto the workpiece, the projected mask image is reduced by f/200 times. Since f550 is larger than f266, the laser cutting area by the UV laser (wavelength: 266 nm) is a little smaller than the mask image area by the visible light (wavelength : 550 nm).

*6 For objectives, whose code number ends with "-6" or larger, the quarter-wavelength plate for M Plan Apo 2x (#02ALN370) and the quarter-wavelength plate for BD Plan Apo 2x (#02ALN380) can be attached.
For objectives, whose code number ends with "-5" or smaller, the quarter-wavelength plate may not be attached.
When the quarter-wavelength plate is attached, the parfocal distance is 95.5 mm, and the working distance is 30 mm.

*7 How to use quarter-wavelength plate:
The quarter-wavelength plate for M Plan Apo 2x (#02ALN370) and the quarter-wavelength plate for BD Plan Apo 2x (#02ALN380) are optional accessories.
Be sure to use a microscope with a coaxial illumination unit and a polarization unit.

1) Remove the metal frame along with the quarter-wave plate from the tip of the objective. Then insert the polarization unit (analyzer and polarizer) into the illumination unit of the microscope. Then adjust the analyzer to the crossed Nicol position. (The brightness of the view field will be low at the crossed Nicol position.)
2) Attach the metal frame along with the quarter-wave plate to the tip of the objective again.
3) Rotate the metal frame along with the quarter-wave plate while observing the view field of the eyepiece so that the brightest view field is obtained.

When performing observation by the transmitted illumination or the dark field illumination, the flare is not reduced by the quarter-wavelength plate.
When the quarter-wavelength plate is attached, the polarization observation cannot be performed.
When the quarter-wavelength plate is attached, Laser Auto Focus (LAF) cannot be used.
When attaching the quarter-wavelength plate, adjust the radial deformation amount of the quarter-wavelength plate by using its longitudinal grooves appropriately, so that the quarter-wavelength plate will not be dropped.

Be sure not to press the quarter-wave plate excessively. Otherwise, the quarter-wave plate may be removed from the metal frame.

3. PLACEMENT OF LENSES

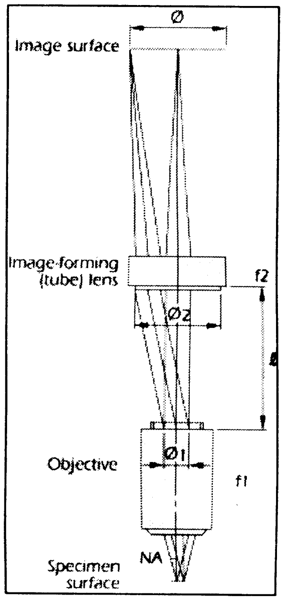
3.1 Placement of objective and tube lens

Use the following formula to calculate the approximate distance, when a distance other than that as pecified 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
$Ø$: Image field



3.2 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:

  $Ø2 > Ø + 2 \cdot f \cdot \tan\theta$

- 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,

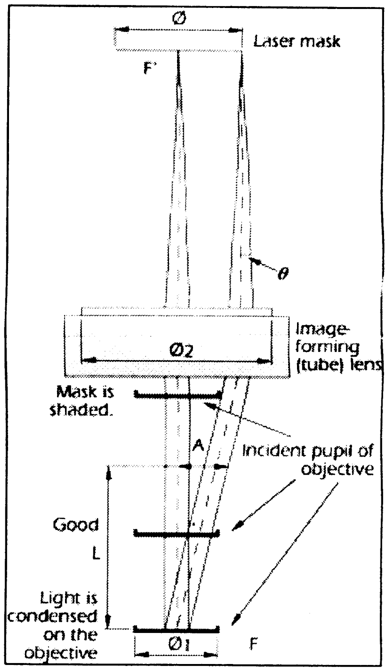
  $A = Ø(L/f) + 2 \cdot f \cdot \tan\theta$,

  At this position, if

  $Ø1 > A$,

  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.



Ø: Laser mask diameter
2 θ: 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

Important

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.

Tip

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

4. PRECAUTIONS FOR USE OF THE LASER

4.1 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/LCD Plan Apo NIR series	**M/LCD Plan Apo NIR series M/LCD Plan Apo NUV series M Plan UV series**	**M/LCD 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/cm^2) Pulse width (10ns)	0.2	0.1	0.05	0.04
Continuous oscillaying laser (CW) Upper limit value of input laser (kW/cm^2)	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/cm^2).

4.2 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.

4.3 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.

4.4 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/cm2).

4.5 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.

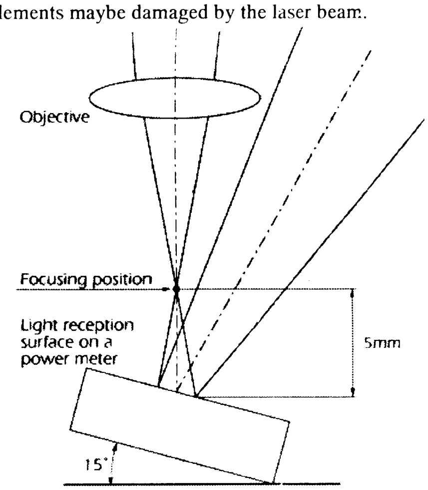
4.6 Precautions on use:

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.



5. Daily Maintenance

Daily maintenance should be done to maximize performance and ensure long and safe use.
Dust and dirt are particularly harmful to the microscope unit. It should be cleaned daily and stored carefully.

(1)Cleaning optical components：Clean lenses, filters, and other optical components as follows.

- Dust：Remove dust on the lenses with a lens brush or by wiping lightly with gauze.
- Fingerprints and oily substances：Fingerprints and oil must be wiped off with alcohol-soaked (ethanol, methanol) lens paper or gauze.

(2) Cleaning metal parts：Lightly wipe metal parts with a silicon cloth.

NOTE Surface discoloration or paint peeling may result if metal parts are cleaned with cleaning agents, solvents or metal polish. Avoid cleaning the instrument in these ways whenever possible.

(3)Storage：When the objectives not in use, store in a case and store in a place where the humidity is low, so mold will not grow.

Printed in Japan
CRFJ408072