

Optem® FMOS

Fixed-Magnification Optical System

Micro-Inspection Lens System

Optem FMOS in offers exceptional value and versatility while offering precision micro-inspection imaging over a broad range of parameters. FMOS consists of a wide range of upper and lower lens modules which, when combined in various configurations, yield a broad variety of static working distances and magnifications at the image plane of your CCD.

FMOS Lower Function Modules offer a variety of manual and motorized focus, illumination, custom configuration and objective integration options. The recent expansion of the FMOS line uses a special adapter for coupling Optem Zoom 125C Lower Modules to the FMOS upper tubes. This provides integration options with larger illuminated FOV's, polarized light and motorized focus.

Min. Mag. Configuration		(FT60 Upper Fixed Tube + B190 Lower Module)	
Magnification Range		0.3X	
Numerical Aperture		0.010	
Resolution		30 lp/mm	
Depth-of-Field		5.8 mm	
Working Distance		195 mm	
FOV (1/3" Camera)		11.9 x 15.9 mm	
FOV (1/2" Camera)		15.9 x 21.2 mm	
FOV (2/3" Camera)		21.9 x 29.2 mm	
FOV (1" Camera)		31.8 x 42.4 mm	
Max. Mag. Configuration		(FTM500 Upper Fixed Tube + Basic Obj Module + 50X MPlan APO Obj.)	
Magnification Range		125X	
Numerical Aperture		0.55	
Resolution		1650 lp/mm	
Depth-of-Field		0.0019 mm	
Working Distance		13 mm	
FOV (1/3" Camera)		0.029 x 0.038 mm	
FOV (1/2" Camera)		0.053 x 0.070 mm	
FOV (2/3" Camera)		0.59 x 0.78 mm	
FOV (1" Camera)		0.077 x 0.10 mm	



Specifying Your Optem FMOS Lens System

To specify your Optem FMOS Fixed-Magnification Lens System identify the parameters of your application and select the modular components which deliver the optimum imaging solution.

STEP 1. Determine the Field-of-View (FOV) you require by choosing your intended camera format (1/3", 1/2", 2/3" etc...), and using the dimensions of that camera format to calculate the optical magnification required (see camera dimensions below):

$$\text{Optical Mag.} = \frac{\text{Camera dimension (mm)}}{\text{FOV desired (mm)}}$$

STEP 2. The FMOS System requires a Fixed Tube and a Lower Function Module. First determine what Lower Function Module you require. Options include; **Basic (B)**, **Coaxial Illumination (C)**, **Internal Focus (F)** and **Internal Focus with Coaxial illumination (FC)**. Note: There are separate [Optical Performance Charts](#) for varying illumination methods and objective integration:

- Oblique (Ring light) or Substage Illumination (p. 06)
- Coaxial Illumination (p. 07)
- Infinity Corrected M PLAN APO Objectives (p. 08)

STEP 3. Choose the appropriate working distance you require for your application. By referring to the Optical Performance Charts TOP AXIS, choose the best working distance (WD). Keeping in mind, the higher resolution (NA) will be achieved with the shorter working distances. (see [Optical Performance Charts](#) p. 06-08).

STEP 4. Select the Fixed Tube: The Fixed Tubes are shown on the LEFT AXIS of all [Optical Performance Charts](#), and each Fixed Tube has an optical focal length associated to it. When combined with the focal length of the lens in the Lower Function Module, the two create a magnification factor. This magnification factor, in relation to your camera format, will yield a specific Field-of-View (FOV), which is displayed in the box where the LEFT AXIS and TOP AXIS intersect.

STEP 5. When completed, you will have identified the following two components required for your functional FMOS Lens System.

- **Fixed Tube**
- **Lower Function Module**

Useful Formulas & Definitions

CAMERA CHIP DIMENSIONS (mm):



DEPTH-OF-FIELD (DOF):

The axial depth of the space on both sides of the object plane within which the object can be moved without objectionable loss of sharpness.

$$\text{DOF} = \lambda \div \text{NA}^2$$

λ = Wavelength of Light (Green Light = 0.000550mm or 550nm)

MAGNIFICATION:

The ratio of image size to actual object size.

$$\begin{aligned}\text{Optical Mag.} &= \text{Camera Chip dim.} \div \text{Field-of-View (FOV)} \\ \text{Electronic Mag.} &= \text{Monitor Diag.} \div \text{Camera Diag.}\end{aligned}$$

NUMERICAL APERTURE (NA):

A measurement of the light collecting ability of the lens. A higher NA translates to a brighter image, better resolution, and shallower depth-of-field.

Components and New Features

Upper Fixed Tubes



FIXED TUBES (FT) – As the upper most component of your Optem FMOS Lens System, Fixed Tubes function to provide the desired magnification factor and correct back focal distance to the sensor of your C-mount camera.

FIXED TUBES, MINI (FTM) – For installations where space is at a premium, Mini Fixed Tubes deliver the same optical performance as FT Fixed Tubes in a fraction of the length.

Lower Function Modules

Lower Function Modules dictate working distance. When configuring your FMOS Lens System, select from a wide array of Function Modules to integrate the specific functionality desired in your Lens System:



BASIC (B) MODULE - This component delivers the most economical and space efficient system when ambient or independent illumination is planned and system focus can be affected through staging.



INTERNAL FOCUS (F) MODULE - Self-contained 10mm manual focus for precision image adjustment without manipulating staging or disturbing image stability.



COAXIAL ILLUMINATION (C) MODULE - Introduces coaxial (vertical) illumination using fiber optic, halogen or LED coaxial illuminators. (See p. 04 and p. 07)

INTERNAL FOCUS, COAXIAL ILLUMINATION (FC)

MODULE - Introduces 10mm manual internal focus with coaxial (vertical) illumination.



OBJECTIVE MODULES - Afford integration of Infinity-Corrected Objectives utilizing one of the following Modules: **Basic Objectives Module**; **Coaxial Illumination Objectives Module**; **Internal Focus Objectives Module**; **Internal Focus, Coaxial Objectives Module**. Objectives Modules feature M26 x 36T threads to accept Optem and Mitutoyo Objectives (See p. 08). An RMS thread adapter is available for Olympus and Nikon Objectives.



VARIABLE WORKING DISTANCE AUXILIARY

LENS - Intended for applications requiring working distances from 127 (5") – 432mm (17"), (See p. 09).

OPTEM ZOOM 125C LOWER MODULE ADAPTER

- Expand the modular flexibility of your FMOS Lens System with the imaging and functional versatility offered by Optem Zoom 125C Lens System Lower Function Modules, including:

- 15mm Manual or motorized fine focus
- 5mm Manual or motorized fine focus with coaxial illumination
- Polarized fiber optic coaxial illumination
- Infinity Macro Lens Accessory (See p. 09)



RESOLUTION:

The ability to distinguish or separate fine detail. Expressed in line pairs per millimeter (lp/mm). Numerical Aperture (NA) is the controlling factor over resolution... the higher the NA, the brighter the image, and the better the resolution.

$$\text{Visual Resolution (lp/mm)} = 3000 \times \text{NA}$$
$$1 \div \text{lp/mm} = \text{Approx. microns } (\mu) \text{ resolved}$$

VIGNETTING:

The blockage of rays from off-axis object points by constraining apertures. Vignetting results in the darkening of the corners on your monitor.



Illumination Options

Illumination Options

The Optem FMOS Lens System offers a variety of illumination options to meet a variety of imaging requirements.



You have two basic illumination options which can be integrated with your FMOS System... coaxial illumination or oblique ringlight illumination.

Coaxial Illumination Options

Coaxial (or vertical) illumination is most useful on highly reflective objects. Optem's Coaxial Illuminators project cool, white light perpendicularly onto the specimen for exceptional contrast and field uniformity (Refer p. 07 for performance).

Select from one of several coaxial-equipped lower function modules when specifying your FMOS lens system and integrate one of the three following options of coaxial illumination (See FMOS System Diagram p 10-11).

LED COAXIAL ILLUMINATORS – Programmable 1-Watt LED Coaxial Illuminators offer reduced power requirements and heat generation with substantial service life gains. LED Coaxial illuminators are available in straight and right-angle configurations to meet your specific space requirements, and feature compact designs and simplified cable management. These can be driven by stand-alone, single-channel programmable controllers. Coaxial LEDs emit brilliant cool light in the visible spectrum and deliver virtually identical optical performance to our fiber optic and halogen Coaxial Illuminators.



FIBER OPTIC COAXIAL ILLUMINATORS – Integrate coaxial illumination from your choice of either 110V or 220V Optem VSI Fiber Optic Illuminators using flexible 40- or 60-inch flexible fiber bundles.

10W HALOGEN COAXIAL ILLUMINATORS – When economy is high priority, Halogen light sources are available with a 6V Variable Transformer (110V / 220V). Ventilated lamphouses are required for use with halogen illuminators (see System Diagram p. 10-11).

POLARIZED LIGHT – When imaging highly reflective subjects, Polarizer Modules with built-in Analyzers are available to introduce polarization to both LED and Fiber Optic Coaxial Illumination paths.

Oblique Ringlight Options

Dark Field Illumination is generally used on 3-D objects to cast light rays at an angle onto an object, thus better defining its surface profile. Optem offers the following dark field illuminators for the FMOS System (Refer p. 06 for performance).

FIBER OPTIC RING LIGHTS – Oblique Ringlight Illumination is ideal to better define features of dimension rich subjects. Driven with the same VSI Fiber Optic Illuminator as conventional coaxial systems, Qioptiq offers Ringlights specifically designed for a variety of configurations, including integration of objectives (see System Diagram p. 10-11).

Motorization and Configuration Accessories



Motorizing Lens System

Optem FMOS Lens Systems can be specified with motorized focus functions utilizing Zoom 125C Lower Function Modules. Select from Stepper or DC Motor options.

STEPPER MOTOR – The stepper motors provide accurate repeatability of zoom magnification and/or focus using a Hall-effect sensor to set repeatable home position. A desktop rocker switch controller offers manual control and features an RS-232 port for automated computer control. Includes controller instructions with a list of RS-232 control commands, a Windows® control program, and startup LabVIEW control program. An OEM controller board version is available for streamlined integration.

DC MOTOR – DC motors provide continuous, fine adjustment and control of focus function. A desktop joystick controller offers simultaneous control of both zoom and focus functions.



Configuration Accessories

Extend the versatility of your FMOS Lens System with two new innovations in form and function.

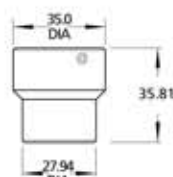
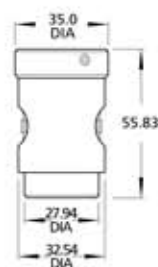
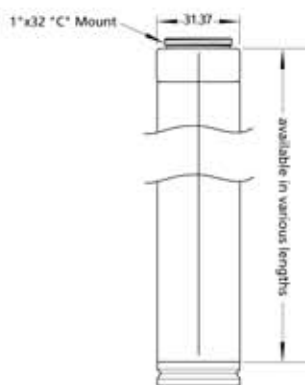
MID-SYSTEM RIGHT-ANGLE MODULE – This accessory allows the introduction of a 90° of your optical axis at the mid-body point of your FMOS Lens System. Users can now integrate any FMOS, Zoom 70XL or Zoom 125C Lower Function Modules below the right-angle turn, maintaining full working distance and affording greater configuration flexibility. *NOTE: the Mid-System Right-Angle Module produces a mirror (reversed) image.*



DUAL-MAGNIFICATION MODULE – Simultaneously integrate two Optem FMOS Fixed Tubes and/or Zoom 70XL Zoom Modules with TV Tube, over a single subject. This permits real-time dual fixed and/or zoom imaging of your object of interest with your choice of magnifications, FOVs, camera formats and camera types. Integrate any of the full range of FMOS, Zoom 70XL and Zoom 125C Lower Function Modules below the Dual-Mag Module, or integrate compact vertical illumination through the compact Dual-Mag coaxial block.



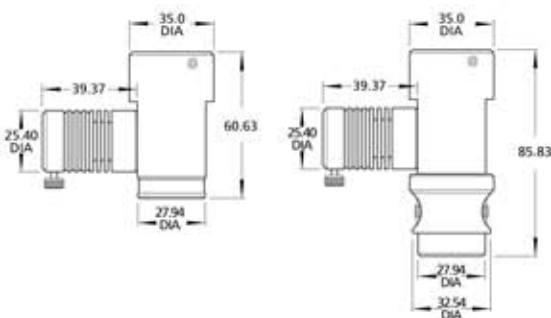
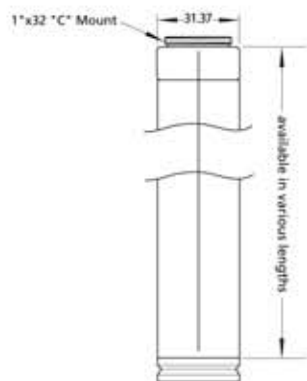
Optical Performance FMOS Substage/Oblique Illumination



		B190/F190 WD: 193 mm	B170/F170 WD: 171 mm	B150/F150 WD: 153 mm	B130/F130 WD: 133 mm	B90/F90 WD: 89 mm	B50/F50 WD: 50 mm	B30/F30 WD: 32 mm
FT60	NA	0.010	0.011	0.013	0.014	0.021	0.033	0.050
	Res Aperture	35	34	38	48	62	98	150
	Magn	0.30	0.34	0.38	0.44	0.63	1.0	1.5
	DOF (mm)	5.8	4.5	3.4	2.8	1.3	0.53	0.23
	FOV (mm)	11.9 x 15.9	10.5 x 14.0	9.39 x 12.5	8.26 x 11.0	5.70 x 7.59	3.60 x 4.80	2.36 x 3.15
FT/FTM 100	NA	0.016	0.018	0.020	0.023	0.034	0.053	0.081
	Res Aperture	48	55	61	70	101	164	244
	Magn	0.40	0.55	0.62	0.71	1.0	1.5	2.5
	DOF (mm)	2.2	1.7	1.4	1.1	0.50	0.20	0.086
	FOV (mm)	17.1 x 22.1	15.1 x 19.1	13.1 x 17.1	11.1 x 14.1	7.1 x 9.1	4.1 x 5.1	2.1 x 2.1
FTM 120	NA	0.020	0.022	0.025	0.029	0.041	0.066	0.10
	Res Aperture	59	67	75	86	124	197	300
	Magn	0.50	0.67	0.75	0.86	1.2	2.0	3.0
	DOF (mm)	1.4	1.1	0.90	0.69	0.33	0.13	0.057
	FOV (mm)	16.2 x 21.6	14.2 x 19.0	12.7 x 17.0	11.2 x 14.9	7.72 x 10.3	4.68 x 6.51	3.20 x 4.27
FT/FTM 140	NA	0.023	0.026	0.029	0.033	0.048	0.075	0.12
	Res Aperture	68	77	87	99	143	226	345
	Magn	0.60	0.79	0.88	1.0	1.5	2.3	3.5
	DOF (mm)	1.1	0.85	0.68	0.53	0.25	0.10	0.043
	FOV (mm)	15.2 x 20.3	13.2 x 17.3	11.7 x 15.7	10.2 x 13.7	6.72 x 9.23	4.18 x 5.58	2.74 x 3.66
FT/FTM 160	NA	0.026	0.029	0.033	0.038	0.054	0.086	0.13
	Res Aperture	78	88	99	113	163	258	394
	Magn	0.70	0.90	1.0	1.1	1.7	2.6	4.0
	DOF (mm)	0.84	0.65	0.52	0.40	0.19	0.077	0.037
	FOV (mm)	14.5 x 19.3	12.5 x 16.3	11.0 x 14.5	9.5 x 12.5	6.2 x 8.2	3.72 x 4.92	2.42 x 3.22
FT/FTM 180	NA	0.030	0.034	0.038	0.043	0.062	0.098	0.15
	Res Aperture	89	101	113	129	187	295	450
	Magn	0.80	1.0	1.1	1.3	1.9	3.0	4.5
	DOF (mm)	0.64	0.50	0.40	0.31	0.15	0.059	0.025
	FOV (mm)	13.7 x 18.7	11.7 x 15.7	10.2 x 13.7	8.7 x 11.7	5.7 x 7.7	3.42 x 4.52	2.22 x 2.92
FT/FTM 200	NA	0.032	0.036	0.041	0.046	0.067	0.11	0.16
	Res Aperture	96	109	123	138	202	320	488
	Magn	1.0	1.3	1.4	1.6	2.3	3.7	5.0
	DOF (mm)	0.55	0.43	0.34	0.26	0.12	0.050	0.021
	FOV (mm)	13.0 x 17.0	11.0 x 14.0	9.5 x 12.5	8.0 x 11.0	5.2 x 7.2	3.12 x 4.12	2.02 x 2.72
FTM 250	NA	0.032	0.036	0.041	0.046	0.067	0.11	0.16
	Res Aperture	96	109	123	138	202	320	488
	Magn	1.2	1.4	1.6	1.8	2.6	4.1	6.0
	DOF (mm)	0.55	0.43	0.34	0.26	0.12	0.050	0.021
	FOV (mm)	12.1 x 16.1	10.1 x 13.1	8.6 x 11.6	7.1 x 10.1	4.7 x 6.7	2.82 x 3.82	1.82 x 2.52
FTM 300	NA	0.032	0.036	0.041	0.046	0.067	0.11	0.16
	Res Aperture	96	109	123	138	202	320	488
	Magn	1.5	1.7	1.9	2.1	3.1	4.9	7.5
	DOF (mm)	0.55	0.43	0.34	0.26	0.12	0.050	0.021
	FOV (mm)	11.2 x 15.2	9.2 x 12.2	7.7 x 10.7	6.2 x 8.7	4.0 x 5.7	2.42 x 3.22	1.52 x 2.02
FTM 350	NA	0.032	0.036	0.041	0.046	0.067	0.11	0.16
	Res Aperture	96	109	123	138	202	320	488
	Magn	1.7	2.0	2.2	2.5	3.6	5.7	8.8
	DOF (mm)	0.55	0.43	0.34	0.26	0.12	0.050	0.021
	FOV (mm)	10.3 x 13.3	8.3 x 11.3	6.8 x 9.3	5.3 x 7.8	3.4 x 4.9	2.02 x 2.72	1.22 x 1.62
FTM 400	NA	0.032	0.036	0.041	0.046	0.067	0.11	0.16
	Res Aperture	96	109	123	138	202	320	488
	Magn	2.0	2.3	2.5	2.8	4.1	6.6	10
	DOF (mm)	0.55	0.43	0.34	0.26	0.12	0.050	0.021
	FOV (mm)	9.4 x 12.4	7.4 x 10.4	6.0 x 8.4	4.5 x 6.4	2.9 x 4.4	1.72 x 2.32	1.02 x 1.42
FTM 450	NA	0.032	0.036	0.041	0.046	0.067	0.11	0.16
	Res Aperture	96	109	123	138	202	320	488
	Magn	2.2	2.5	2.8	3.2	4.7	7.4	11
	DOF (mm)	0.55	0.43	0.34	0.26	0.12	0.050	0.021
	FOV (mm)	8.5 x 11.5	6.5 x 9.5	5.0 x 7.0	3.5 x 5.0	2.2 x 3.2	1.32 x 1.82	0.82 x 1.12
FTM 500	NA	0.032	0.036	0.041	0.046	0.067	0.11	0.16
	Res Aperture	96	109	123	138	202	320	488
	Magn	2.5	2.8	3.1	3.6	5.2	8.2	13
	DOF (mm)	0.55	0.43	0.34	0.26	0.12	0.050	0.021
	FOV (mm)	7.6 x 10.6	5.6 x 8.6	4.1 x 5.6	2.6 x 4.1	1.6 x 2.6	0.92 x 1.22	0.52 x 0.72

Optical Performance

FMOS Coaxial Illumination



		R190/F190 WD: 190 mm	R170/F170 WD: 170 mm	R150/F150 WD: 150 mm	R130/F130 WD: 130 mm	R90/F90 WD: 90 mm	R50/F50 WD: 50 mm	R30/F30 WD: 30 mm
FT60	NA	0.018	0.011	0.013	0.014	0.021	0.023	0.050
	Max (µm)	30	34	38	43	62	98	150
	Mag	0.30	0.34	0.38	0.44	0.63	1.0	1.5
	DOF (mm)	5.8	8.5	1.6	2.8	1.2	0.53	0.23
	FOV (mm)	101°	105° x 14.0	9.39° x 12.5	8.26° x 11.0	5.70° x 7.59	3.60° x 4.80	2.36° x 3.15
FT/FTM 100	NA	0.016	0.018	0.020	0.023	0.034	0.053	0.081
	Max (µm)	48	55	61	70	101	160	244
	Mag	0.49	0.55	0.62	0.71	1.0	1.6	2.5
	DOF (mm)	2.2	1.3	1.4	1.1	0.50	0.20	0.086
	FOV (mm)	101°	7.26° x 9.82	5.49° x 8.66	5.80° x 7.73	5.10° x 6.80	3.52° x 2.96	1.46° x 1.94
FTM 120	NA	0.020	0.022	0.025	0.029	0.041	0.066	0.10
	Max (µm)	59	67	75	86	124	197	300
	Mag	0.59	0.67	0.75	0.86	1.2	2.0	3.0
	DOF (mm)	1.4	1.1	0.90	0.69	0.33	0.13	0.057
	FOV (mm)	101°	8.26° x 8.08	5.75° x 7.13	4.77° x 6.36	4.20° x 5.60	2.90° x 3.86	1.83° x 2.44
FT/FTM 140	NA	0.021	0.026	0.029	0.033	0.048	0.075	0.12
	Max (µm)	66	77	87	99	143	226	345
	Mag	0.69	0.79	0.88	1.0	1.5	2.3	3.5
	DOF (mm)	1.1	0.89	0.68	0.53	0.25	0.10	0.043
	FOV (mm)	101°	5.20° x 6.93	4.58° x 6.11	4.09° x 5.45	3.60° x 4.80	2.48° x 3.31	1.57° x 2.09
FT/FTM 160	NA	0.028	0.029	0.033	0.038	0.054	0.086	0.13
	Max (µm)	78	88	99	113	163	258	394
	Mag	0.78	0.90	1.0	1.1	1.7	2.6	4.0
	DOF (mm)	0.84	0.65	0.52	0.40	0.19	0.077	0.033
	FOV (mm)	101°	4.55° x 6.06	4.01° x 5.25	3.58° x 4.77	3.15° x 4.20	2.17° x 2.96	1.37° x 1.83
FT/FTM 180	NA	0.030	0.034	0.038	0.043	0.062	0.098	0.15
	Max (µm)	89	101	113	129	183	295	450
	Mag	0.89	1.0	1.1	1.3	1.9	3.0	4.5
	DOF (mm)	0.64	0.50	0.40	0.31	0.15	0.059	0.025
	FOV (mm)	101°	4.04° x 5.39	3.56° x 4.75	3.18° x 4.24	2.80° x 3.73	1.93° x 2.57	1.22° x 1.63
FT/FTM 200	NA	0.032	0.036	0.041	0.046	0.067	0.11	0.16
	Max (µm)	96	109	123	139	202	320	488
	Mag	1.0	1.1	1.3	1.4	2.1	3.5	5.0
	DOF (mm)	0.55	0.43	0.34	0.26	0.12	0.050	0.021
	FOV (mm)	101°	3.64° x 4.85	3.21° x 4.28	2.86° x 3.82	2.52° x 3.36	1.74° x 2.32	1.10° x 1.46
FTM 250	NA	0.032	0.036	0.041	0.046	0.067	0.11	0.16
	Max (µm)	96	109	123	139	202	320	488
	Mag	1.2	1.4	1.6	1.8	2.6	4.1	6.3
	DOF (mm)	0.55	0.43	0.34	0.26	0.12	0.050	0.021
	FOV (mm)	101°	2.91° x 3.88	2.57° x 3.42	2.29° x 3.05	2.02° x 2.69	1.39° x 1.85	0.88° x 1.17
FTM 300	NA	0.032	0.036	0.041	0.046	0.067	0.11	0.16
	Max (µm)	96	109	123	139	202	320	488
	Mag	1.5	1.7	1.9	2.1	3.1	4.9	7.5
	DOF (mm)	0.55	0.43	0.34	0.26	0.12	0.050	0.021
	FOV (mm)	101°	2.43° x 3.23	2.14° x 2.85	1.91° x 2.55	1.68° x 2.24	1.16° x 1.54	0.73° x 0.98
FTM 350	NA	0.032	0.036	0.041	0.046	0.067	0.11	0.16
	Max (µm)	96	109	123	139	202	320	488
	Mag	1.7	2.0	2.2	2.5	3.6	5.7	8.8
	DOF (mm)	0.55	0.43	0.34	0.26	0.12	0.050	0.021
	FOV (mm)	101°	2.08° x 2.77	1.83° x 2.44	1.64° x 2.18	1.44° x 1.92	0.99° x 1.32	0.63° x 0.84
FTM 400	NA	0.032	0.036	0.041	0.046	0.067	0.11	0.16
	Max (µm)	96	109	123	139	202	320	488
	Mag	2.0	2.2	2.5	2.9	4.1	6.6	10
	DOF (mm)	0.55	0.43	0.34	0.26	0.12	0.050	0.021
	FOV (mm)	101°	1.82° x 2.43	1.60° x 2.14	1.43° x 1.91	1.26° x 1.68	0.87° x 1.16	0.55° x 0.73
FTM 450	NA	0.032	0.036	0.041	0.046	0.067	0.11	0.16
	Max (µm)	96	109	123	139	202	320	488
	Mag	2.2	2.5	2.8	3.2	4.7	7.4	11
	DOF (mm)	0.55	0.43	0.34	0.26	0.12	0.050	0.021
	FOV (mm)	101°	1.62° x 2.16	1.43° x 1.90	1.27° x 1.70	1.12° x 1.49	0.77° x 1.03	0.49° x 0.65
FTM 500	NA	0.032	0.036	0.041	0.046	0.067	0.11	0.16
	Max (µm)	96	109	123	139	202	320	488
	Mag	2.5	2.8	3.1	3.6	5.2	8.2	13
	DOF (mm)	0.55	0.43	0.34	0.26	0.12	0.050	0.021
	FOV (mm)	101°	1.46° x 1.94	1.28° x 1.71	1.15° x 1.53	1.01° x 1.34	0.69° x 0.93	0.44° x 0.59

07

-- Not recommended due to significant illumination losses.

-- FOV limited by illumination. Approximate maximum illuminated FOV given as diameter at top of chart.

Max FOV at Low Mag (Dia.): 7.0 mm ø 7.0 mm ø 7.0 mm ø 7.0 mm ø 9.0 mm ø 9.0 mm ø 9.0 mm ø

FMOS Coaxial with LWD M-Plan APO Objectives Optical Performance

Achieve significantly higher magnifications and increased resolution. Combine your FMOS with the expanded line of Optem LWD Infinity-Corrected Objectives.

OPTM M-PLAN APO – Eliminate chromatic aberration across exceptionally flat fields for the ultimate in high-magnification accuracy. Select from 2X, 5X, 10X, 20X and 50X Long-Working Distance Objectives. These objectives are exact replacements for Mitutoyo 378 series objectives and are ideal for metrology applications.

LWD Infinity-Corrected M-Plan APO Objectives

28-21-02-000	2X M Plan APO, LWD
28-21-05-000	5X M Plan APO, LWD
28-21-10-000	10X M Plan APO, LWD
28-21-11-000	20X M Plan APO, LWD
28-21-50-000	50X M Plan APO, LWD



		2X M Plan APO 28-21-02-000 WD: 34 mm	5X M Plan APO 28-21-05-000 WD: 34 mm	10X M Plan APO 28-21-10-000 WD: 34 mm	20X M Plan APO 28-21-11-000 WD: 29 mm	50X M Plan APO 28-21-50-000 WD: 13 mm
FT60	NA	0.020	0.050	0.10	0.20	0.50
	Res. Surface	60	150	300	600	1500
	Magn.	0.61	1.5	3.1	6.1	15
	DOF (mm)	1.4	0.23	0.057	0.014	0.0023
	FOV (mm)	100° 5.90 x 7.87 100° 7.87 x 10.5 200° 10.8 x 14.4 1° 75.7 x 21.0	100° 2.36 x 3.15 100° 3.15 x 4.20 200° 4.23 x 5.77 1° 6.30 x 8.39	100° 1.18 x 1.57 100° 2.10 x 2.79 200° 2.79 x 3.78 1° 3.15 x 4.20	100° 0.59 x 0.79 100° 1.05 x 1.37 200° 1.37 x 1.84 1° 1.57 x 2.10	100° 0.24 x 0.31 100° 0.31 x 0.42 200° 0.42 x 0.58 1° 0.58 x 0.75
FT/FTM 100	NA	0.033	0.081	0.16	0.33	0.55
	Res. Surface	98	244	488	975	1600
	Magn.	0.99	2.5	4.9	9.9	24.7
	DOF (mm)	0.54	0.086	0.021	0.0054	0.0019
	FOV (mm)	100° 3.64 x 4.86 100° 4.86 x 6.48 200° 6.48 x 8.64 1° 9.72 x 13.0	100° 1.86 x 2.48 100° 2.48 x 3.31 200° 3.31 x 4.41 1° 3.89 x 5.18	100° 0.93 x 1.24 100° 1.30 x 1.78 200° 1.78 x 2.37 1° 2.59 x 3.45	100° 0.36 x 0.49 100° 0.49 x 0.65 200° 0.65 x 0.89 1° 1.30 x 1.78	100° 0.15 x 0.19 100° 0.19 x 0.26 200° 0.26 x 0.36 1° 0.36 x 0.52
FTM 120	NA	0.040	0.10	0.20	0.40	0.55
	Res. Surface	120	300	600	1200	1650
	Magn.	1.2	3.0	6.0	12	30
	DOF (mm)	0.35	0.057	0.014	0.0035	0.0019
	FOV (mm)	100° 3.00 x 4.00 100° 4.00 x 5.33 200° 5.33 x 7.11 1° 8.00 x 10.7	100° 1.20 x 1.60 100° 1.60 x 2.13 200° 2.13 x 2.84 1° 3.20 x 4.27	100° 0.60 x 0.80 100° 1.07 x 1.41 200° 1.41 x 1.87 1° 2.13 x 2.84	100° 0.30 x 0.40 100° 0.53 x 0.71 200° 0.71 x 0.93 1° 1.07 x 1.41	100° 0.12 x 0.16 100° 0.16 x 0.21 200° 0.21 x 0.29 1° 0.32 x 0.43
FT/FTM 140	NA	0.046	0.12	0.23	0.42	0.55
	Res. Surface	138	345	690	1260	1650
	Magn.	1.4	3.5	7.0	14	35
	DOF (mm)	0.27	0.043	0.011	0.0032	0.0019
	FOV (mm)	100° 2.57 x 3.43 100° 3.43 x 4.57 200° 4.57 x 6.29 1° 6.86 x 9.14	100° 1.03 x 1.37 100° 1.37 x 1.83 200° 1.83 x 2.51 1° 2.74 x 3.68	100° 0.51 x 0.69 100° 0.69 x 0.91 200° 0.91 x 1.26 1° 1.26 x 1.69	100° 0.26 x 0.34 100° 0.34 x 0.46 200° 0.46 x 0.63 1° 0.63 x 0.84	100° 0.10 x 0.14 100° 0.14 x 0.18 200° 0.18 x 0.25 1° 0.25 x 0.37
FT/FTM 160	NA	0.053	0.13	0.26	0.42	0.55
	Res. Surface	158	394	788	1260	1650
	Magn.	1.6	4.0	8.0	16	40
	DOF (mm)	0.21	0.039	0.0092	0.0032	0.0019
	FOV (mm)	100° 2.25 x 3.00 100° 3.00 x 4.00 200° 4.00 x 5.33 1° 6.00 x 8.00	100° 0.90 x 1.20 100° 1.20 x 1.60 200° 1.60 x 2.13 1° 2.40 x 3.20	100° 0.45 x 0.60 100° 0.60 x 0.80 200° 0.80 x 1.10 1° 1.20 x 1.60	100° 0.23 x 0.30 100° 0.30 x 0.40 200° 0.40 x 0.55 1° 0.60 x 0.80	100° 0.09 x 0.12 100° 0.12 x 0.16 200° 0.16 x 0.22 1° 0.24 x 0.32
FT/FTM 180	NA	0.055	0.14	0.30	0.42	0.55
	Res. Surface	165	420	900	1260	1650
	Magn.	1.8	4.5	9.0	18	45
	DOF (mm)	0.19	0.029	0.0063	0.0032	0.0019
	FOV (mm)	100° 2.00 x 2.67 100° 2.67 x 3.56 200° 3.56 x 4.75 1° 5.33 x 7.11	100° 0.80 x 1.07 100° 1.07 x 1.42 200° 1.42 x 1.86 1° 2.13 x 2.84	100° 0.40 x 0.53 100° 0.53 x 0.71 200° 0.71 x 0.98 1° 1.07 x 1.42	100° 0.20 x 0.27 100° 0.27 x 0.36 200° 0.36 x 0.49 1° 0.49 x 0.63	100° 0.08 x 0.11 100° 0.11 x 0.14 200° 0.14 x 0.20 1° 0.20 x 0.28
FT/FTM 200	NA	0.055	0.14	0.30	0.42	0.55
	Res. Surface	165	420	900	1260	1650
	Magn.	2.0	5.0	10	20	50
	DOF (mm)	0.19	0.029	0.0063	0.0032	0.0019
	FOV (mm)	100° 1.80 x 2.40 100° 2.40 x 3.20 200° 3.20 x 4.40 1° 4.80 x 6.40	100° 0.72 x 0.96 100° 0.96 x 1.28 200° 1.28 x 1.76 1° 2.56 x 3.44	100° 0.36 x 0.48 100° 0.48 x 0.64 200° 0.64 x 0.88 1° 0.96 x 1.28	100° 0.18 x 0.24 100° 0.24 x 0.32 200° 0.32 x 0.44 1° 0.48 x 0.64	100° 0.07 x 0.10 100° 0.10 x 0.13 200° 0.13 x 0.18 1° 0.18 x 0.26
FTM 250	NA	0.055	0.14	0.30	0.42	0.55
	Res. Surface	165	420	900	1260	1650
	Magn.	2.5	6.3	13	25	63
	DOF (mm)	0.19	0.029	0.0063	0.0032	0.0019
	FOV (mm)	100° 1.44 x 1.92 100° 1.92 x 2.56 200° 2.56 x 3.52 1° 3.84 x 5.12	100° 0.56 x 0.77 100° 0.77 x 1.02 200° 1.02 x 1.41 1° 1.54 x 2.05	100° 0.28 x 0.38 100° 0.38 x 0.51 200° 0.51 x 0.70 1° 0.77 x 1.02	100° 0.14 x 0.19 100° 0.19 x 0.26 200° 0.26 x 0.35 1° 0.35 x 0.47	100° 0.058 x 0.077 100° 0.077 x 0.10 200° 0.10 x 0.14 1° 0.14 x 0.20
FTM 300	NA	0.055	0.14	0.30	0.42	0.55
	Res. Surface	165	420	900	1260	1650
	Magn.	3.0	7.5	15	30	75
	DOF (mm)	0.19	0.029	0.0063	0.0032	0.0019
	FOV (mm)	100° 1.20 x 1.60 100° 1.60 x 2.13 200° 2.13 x 2.84 1° 3.20 x 4.27	100° 0.48 x 0.64 100° 0.64 x 0.86 200° 0.86 x 1.12 1° 1.28 x 1.71	100° 0.24 x 0.32 100° 0.32 x 0.43 200° 0.43 x 0.59 1° 0.64 x 0.85	100° 0.12 x 0.16 100° 0.16 x 0.21 200° 0.21 x 0.29 1° 0.29 x 0.43	100° 0.048 x 0.064 100° 0.064 x 0.085 200° 0.085 x 0.12 1° 0.12 x 0.17
FTM 350	NA	0.055	0.14	0.30	0.42	0.55
	Res. Surface	165	420	900	1260	1650
	Magn.	3.5	8.8	18	35	88
	DOF (mm)	0.19	0.029	0.0063	0.0032	0.0019
	FOV (mm)	100° 1.03 x 1.37 100° 1.37 x 1.83 200° 1.83 x 2.44 1° 2.74 x 3.68	100° 0.41 x 0.55 100° 0.55 x 0.73 200° 0.73 x 1.01 1° 1.10 x 1.46	100° 0.21 x 0.27 100° 0.27 x 0.37 200° 0.37 x 0.50 1° 0.55 x 0.73	100° 0.10 x 0.14 100° 0.14 x 0.18 200° 0.18 x 0.25 1° 0.25 x 0.37	100° 0.041 x 0.055 100° 0.055 x 0.073 200° 0.073 x 0.10 1° 0.10 x 0.15
FTM 400	NA	0.055	0.14	0.30	0.42	0.55
	Res. Surface	165	420	900	1260	1650
	Magn.	4.0	10	20	40	100
	DOF (mm)	0.19	0.029	0.0063	0.0032	0.0019
	FOV (mm)	100° 0.90 x 1.20 100° 1.20 x 1.60 200° 1.60 x 2.13 1° 2.40 x 3.20	100° 0.36 x 0.48 100° 0.48 x 0.64 200° 0.64 x 0.88 1° 0.96 x 1.28	100° 0.18 x 0.24 100° 0.24 x 0.32 200° 0.32 x 0.44 1° 0.48 x 0.64	100° 0.090 x 0.12 100° 0.12 x 0.16 200° 0.16 x 0.22 1° 0.22 x 0.32	100° 0.036 x 0.048 100° 0.048 x 0.064 200° 0.064 x 0.088 1° 0.088 x 0.13
FTM 450	NA	0.055	0.14	0.30	0.42	0.55
	Res. Surface	165	420	900	1260	1650
	Magn.	4.5	11	23	45	111
	DOF (mm)	0.19	0.029	0.0063	0.0032	0.0019
	FOV (mm)	100° 0.80 x 1.07 100° 1.07 x 1.42 200° 1.42 x 1.96 1° 2.18 x 2.84	100° 0.32 x 0.43 100° 0.43 x 0.57 200° 0.57 x 0.78 1° 0.85 x 1.14	100° 0.16 x 0.21 100° 0.21 x 0.28 200° 0.28 x 0.39 1° 0.43 x 0.57	100° 0.080 x 0.11 100° 0.11 x 0.14 200° 0.14 x 0.20 1° 0.20 x 0.28	100° 0.032 x 0.043 100° 0.043 x 0.057 200° 0.057 x 0.078 1° 0.078 x 0.11
FTM 500	NA	0.055	0.14	0.30	0.42	0.55
	Res. Surface	165	420	900	1260	1650
	Magn.	5.0	13	25	50	125
	DOF (mm)	0.19	0.029	0.0063	0.0032	0.0019
	FOV (mm)	100° 0.72 x 0.96 100° 0.96 x 1.28 200° 1.28 x 1.76 1° 1.92 x 2.56	100° 0.29 x 0.38 100° 0.38 x 0.51 200° 0.51 x 0.70 1° 0.77 x 1.02	100° 0.14 x 0.19 100° 0.19 x 0.26 200° 0.26 x 0.35 1° 0.35 x 0.51	100° 0.072 x 0.096 100° 0.096 x 0.13 200° 0.13 x 0.18 1° 0.18 x 0.26	100° 0.029 x 0.038 100° 0.038 x 0.051 200° 0.051 x 0.070 1° 0.070 x 0.10

– Not recommended due to significant illumination losses.

– FOV limited by illumination. Approximate maximum illuminated FOV given as diameter at top of chart.

Optical Performance

Infinity Macro Lens Accessory

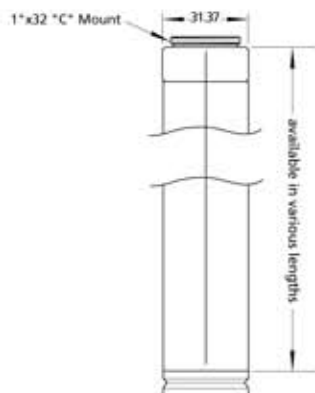
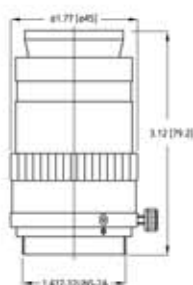
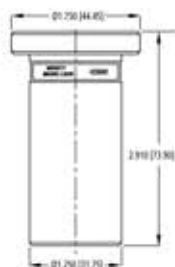
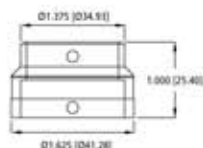


Working Distance	Magnification*
50 mm	0.37X
100 mm	0.25X
150 mm	0.18X
200 mm	0.14X
300 mm	0.1X
400 mm	0.08X

* Magnification factor is relative to B90/F90 values as shown on p. 06.

Beyond 500 mm, the lens can be thought of as a video lens with focal lengths and f# as follows:

Working Distance	EFL Low	EFL High	F# Low	F# High
500mm	18	165	13.8	33
1m	18	190	13.8	33
10m to infinity	18	225	13.8	33



Optical Performance

Variable Working Distance Lower Module

Working Distance	Magnification*
5"	0.288X
6"	0.253X
7"	0.226X
8"	0.202X
9"	0.184X
10"	0.169X
11"	0.158X
12"	0.147X
13"	0.138X
14"	0.130X
15"	0.123X
16"	0.116X
17"	0.109X

* Magnification factor is relative to B90/F90 values as shown on p. 06.



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