MicroSpot *FOCUSING OBJECTIVES*

APPLICATIONS

- ❑ *Micromachining*
- ❑ *Microlithography*
- ❑ *Laser scribing*
- ❑ *Photoablation*

MAJOR FEATURES

- ❑ *For UV excimer & high-power YAG*
- ❑ *Long working distance*
- ❑ *All refractive models*
- ❑ *UV achromatic models*
- ❑ *Video monitoring*

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MicroSpot Focusing Objectives, manufactured in USA by OFR.

Classical Microscope Objectives versus OFR MicroSpot Focusing Objectives

Modern industrial laser applications impose stringent demands on the microscope objective. Cemented elements and oil-immersed lenses severely limit the utility of the traditional objective with high-power UV and IR lasers.

With lens elements made in excimer-grade materials (fused silica and CaF_2), OFR's MicroSpot Focusing Objectives are designed for use with UV, Visible, IR or high-power YAG lasers. MicroSpot Objectives are increasingly used for micromachining, laser scribing and microlithography.

An important feature of OFR MicroSpot Objectives is long working distance, the advantage of which is to minimize vapor deposition on the first lens surface resulting from ablated material. Also, this extra space allows insertion of protective windows, tools and other devices.

	OFR MicroSpot Focusing Objectives	Classical Microscope Objective Application
Spectrum	UV, Visible or IR	Visible only
Optical Power	Low or High Power	Low Power only
Object	Target to be focused upon	To be viewed
Conjugates	Infinite	Finite
Video Monitoring	Yes	Yes

MicroSpot Focusing Objectives

MicroSpot Focusing Objectives, designed and manufactured by OFR since 1988...

DESIGNED FOR UV AND HIGH POWER

Traditional microscope objectives are designed for direct imaging by the eye. Because they contain high-index flint glasses, cemented interfaces or oil-immersed lenses, they are limited to low-power, visible spectrum applications. In contrast, OFR MicroSpot Focusing Objectives do not use cemented interfaces, and thus are well suited for high-power UV and YAG lasers.

EXCIMER-GRADE OPTICAL MATERIALS

The lens elements in OFR LMU and LMUL Series UV Achromatic Objectives are made of excimer-grade fused silica and CaF_2, resulting in superior performance with high-power excimer lasers. All lenses are air-spaced.

YAG LASER APPLICATIONS

Lenses in the LMH Series YAG Laser Objectives are made of the same fused silica as OFR high-power YAG Laser Lenses (See PRECISION OPTICAL COMPONENTS catalog). With high-energy damage resistant AR coatings, LMH Objectives are designed for use with high power YAG lasers.

AR-COATED FOR OPERATING WAVELENGTH

Unlike traditional microscope objectives that are AR coated only for the visible spectrum, all OFR MicroSpot Objectives are coated for the wavelength of operation.

LONG WORKING DISTANCE

Short working distances of traditional objectives create problems in ablative applications (such as laser trimming or semi-conductor circuit shaping). OFR LMU UV Achromatic Objectives have long working distances that help to minimize vapor deposition on the front lens surface. For extreme cases, the LMUL Ultra-Long Objective has the longest working distance for its magnification.

All OFR MicroSpot Objectives are designed for use with a collimated laser beam, that is, they are infinite conjugate objectives.

OFR MicroSpot Focusing Objectives

- ❏ HIGH NA, LONG WORKING DISTANCE, HIGH-POWER CAPABILITY. In order to meet modern requirements for high NA, with long working distance and high-power capability, OFR designed the MicroSpot Focusing Objective product line.
- ❏ LMU and LMUL Series UV ACHROMATIC OBJECTIVES are designed for long working distance, diffraction limited performance with high-power, UV excimer lasers.
- ❏ LMH Series HIGH POWER Nd:YAG LASER OBJECTIVES are designed for diffraction limited performance and maximum power handling capability when used with industrial Nd:YAG lasers.

LMU and LMUL MicroSpot Focusing Objectives

All OFR MicroSpot Focusing Objectives...

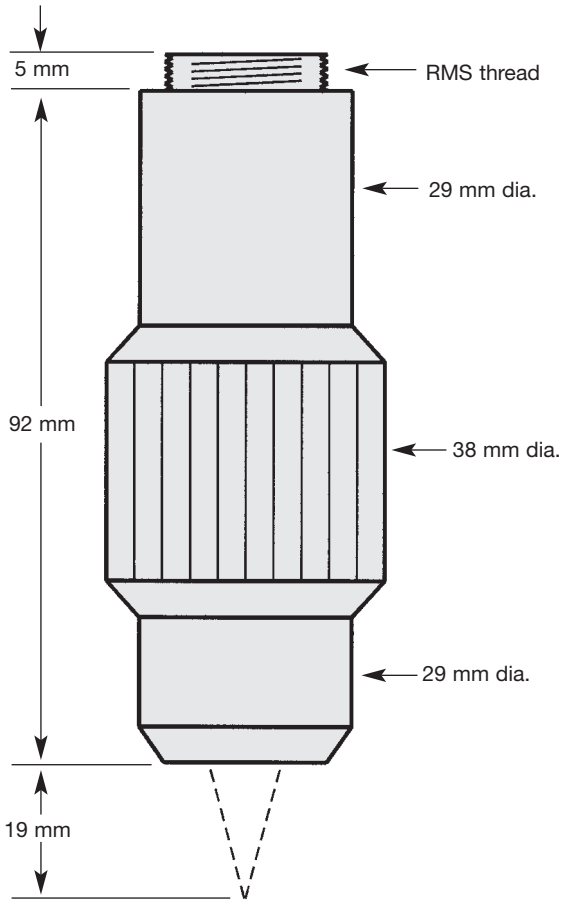
- ❏ Consist of air-spaced components, with no cemented interfaces to limit usable laser power.
- ❏ Designed for use with lasers (infinite conjugate).
- ❏ Can be used with video monitoring.
- ❏ Equipped with the universal standard Royal Microscope Society (RMS) thread (Whitworth 0.8" x 36 TPI).

LMU-Series UV Achromatic Objectives

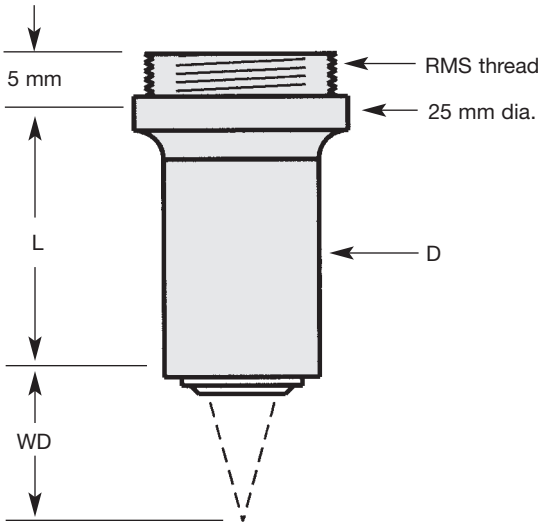
OFR's all-refractive UV Achromatic MicroSpot Focusing Objectives are designed for use with high power, UV excimer lasers and other ultraviolet sources.

SPECIFICATIONS

Materials	Excimer-Grade Fused Silica Excimer-Grade Calcium Fluoride
Design Spectrum	193 nm to 450 nm
Energy Throughput	96-98%



LMUL-20X
Ultra Long-Working Distance
(λ>240 nm, no NUV)



LMU-Series

Lens elements comprising the LMU Objectives are made from the highest quality, lowest absorption excimer grade fused silica and CaF_2 available. For information on material testing under high power UV radiation, the following are recommended:

- "Optical Materials for Excimer Laser Applications" M. Rothschild, Optics & Photonics News, May, 1993
- "Long-Term Effects of Pulsed KrF Laser Radiation on Crystalline and Amorphous SiO_2". D.J. Krajnovich, I.K. Pour, SPIE Vol. 2114, Proceedings, 1993 Boulder Damage Symposium
- "Excimer Lasers: Applications, Beam Delivery Systems and Laser Design" SPIE Vol. 1835, Proceedings, Nov. 1992 Boston Conference
- "Improvements in Crystal Optics for Excimer Lasers" Toepke, D. Cope, Harshaw/Bicron Crystal Products Group

UV MicroSpot FOCUSING OBJECTIVES

Catalog Number	Working Distance	Effective Focal Length	Theoretical Numerical Aperture	Focal Spot Diameter	Entrance Aperture	D	L
† LMU-3X-λ	49 mm	60 mm	0.08	5 µm*	10 mm	21 mm	28 mm
LMU-5X-λ	35 mm	40 mm	0.13	3 µm*	10 mm	21 mm	28 mm
† LMU-10X-λ	15 mm	20 mm	0.25	2 µm*	10 mm	21 mm	42 mm
† LMU-15X-λ	8.5 mm	13 mm	0.32	1 µm*	8.5 mm	21 mm	40 mm
LMU-20X-λ	4 mm	10 mm	0.40	1 µm*	8 mm	21 mm	39 mm
LMU-40X-λ	1 mm	5 mm	0.50	1 µm*	5 mm	21 mm	38 mm
LMUL-20X-λ	19 mm	10 mm	0.40	Discuss	8 mm	see drawing	

When ordering, specify coating according to wavelength and power rating by adding the appropriate coating code, for example, LMUL-20X-266 or LMU-10X-UVB.

* Note that Theoretical Focal Spot Diameter values are based on a Gaussian profile input beam at Design Wavelength which fills the Entrance Aperture at the $1/e^2$ limits.

† ZERO-POWER ACHROMATIZER available, See page 7.

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Antireflection Coatings

MicroSpot Objectives are supplied with high energy-resistant, multilayer antireflection coatings optimized for either a specific excimer laser wavelength or a broadband range of wavelengths within the design spectrum. Standard coatings are shown below. When ordering, replace the "λ" at the end of the part number with the appropriate wavelength (nm) or coating code.

Transmission is more than adequate for video monitoring in the visible. For use outside the UV design spectrum, discuss with OFR.

Contact OFR for information concerning direct and remote monitoring, and individual model performance at other wavelengths.

ANTIREFLECTION COATINGS

NARROWBAND AR COATINGS

Center Wavelength	Bandwidth	Per surface Maximum Reflectance	Power Rating
193 nm (ArF)	192-194 nm	<1.5%	100 MW/cm²
248 nm (KrF)	240-260 nm	<0.5%	200 MW/cm²
257 nm			
266 nm (Nd:YAG)	255-280 nm	<0.35%	500 MW/cm²
308 nm (XeCl)	288-319 nm	<0.25%	500 MW/cm²
351 nm (XeF)	340-370 nm	<0.25%	500 MW/cm²
354 nm (Nd:YAG)	340-370 nm	<0.25%	500 MW/cm²

BROADBAND AR COATINGS

Coating Code	Bandwidth	Per surface Maximum Reflectance	Power Rating
UVB	240-360 nm	1.5%	50 MW/cm²
NUV*	325-500 nm	1 %	50 MW/cm²

*Not available on LMUL-20X.
NOTE: Power rating based upon 20 n-s pulses, 20 Hz.

TRANSMISSION OF LMU SERIES OBJECTIVES

HIGH POWER AR COATINGS

Objective	Transmission
LMU-5X-193	90%
LMU-40X-193	80%
LMU-5X-248	94%
LMU-40X-248	86%
LMU-5X-266	94%
LMU-40X-266	86%

Note

Transmission depends on beam diameter and characteristics, and therefore is not completely predictable. Please inquire.

BROADBAND AR COATINGS (LOW POWER ONLY)

	240-360 nm		325-500 nm
LMU-5X-UVB	>90%	LMU-5X-NUV	>92%
LMU-40X-UVB	>80%	LMU-40X-NUV	>86%

LMH-Series High Power YAG Laser Objectives

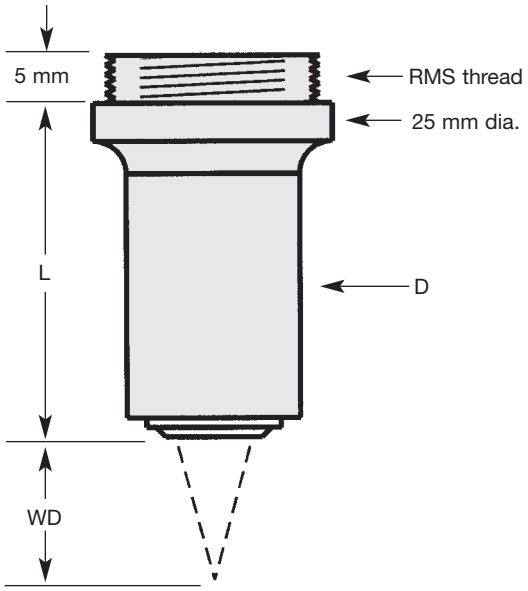
OFR High Power Nd:YAG MicroSpot Focusing Objectives are designed to transmit and focus the high power radiation emitted by industrial Nd:YAG lasers.

Materials	Energy Throughput	Coating	Damage Threshold
Fused Silica	>96-98% within design spectrum	High power damage-resistant, multilayer antireflection coating optimized for 532 nm or 1064 nm. Other coatings available upon request.	500 MW/cm^2 NOTE: Power rating based upon 20 n-s pulses, 20 Hz, 532nm or 1064 nm.

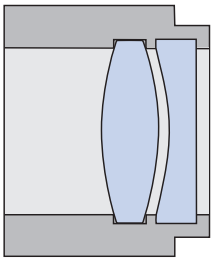
Use Outside the Design Spectrum
The High Power Nd:YAG Objectives are designed for diffraction-limited performance at 1064 nm. Near-diffraction limited performance can be achieved outside the design spectrum, including the visible spectrum. Inquire.

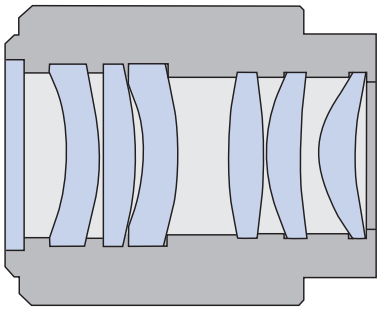
Focal length at 532 nm is 2% shorter than at 1064 µm.

Contact OFR for information concerning direct and remote monitoring and individual model performance at other wavelengths.



LMH-Series


LMH-5X


LMH-20X

HIGH POWER Nd:YAG LASER MicroSpot FOCUSING OBJECTIVES

Catalog Number	Working Distance	Effective Focal Length	Numerical Aperture	Theoretical Focal Spot Diameter	Entrance Aperture	D	L
LMH-5X-532 or 1064	35 mm	40 mm	0.13	12 µm*	10 mm	21 mm	28 mm
LMH-10X-532 or 1064	15 mm	20 mm	0.25	6 µm*	10 mm	21 mm	28 mm
LMH-20X-532 or 1064	6 mm	10 mm	0.40	4 µm*	8 mm	21 mm	38 mm

* Note that Theoretical Focal Spot Diameter values are based on a Gaussian profile input beam at Design Wavelength which fills the Entrance Aperture at the 1/e^2 limits.

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Video Beamsplitters For Visual Monitoring with Camera

UV/VIDEO BEAMSPLITTERS
OFR high-power damage resistant 45° MAX Reflectors/Dichroic Beamsplitters serve a dual purpose, and are used in applications requiring visual monitoring of action on an object in the focal plane of a MicroSpot Objective. The substrates are 6.3 mm thick fused silica.

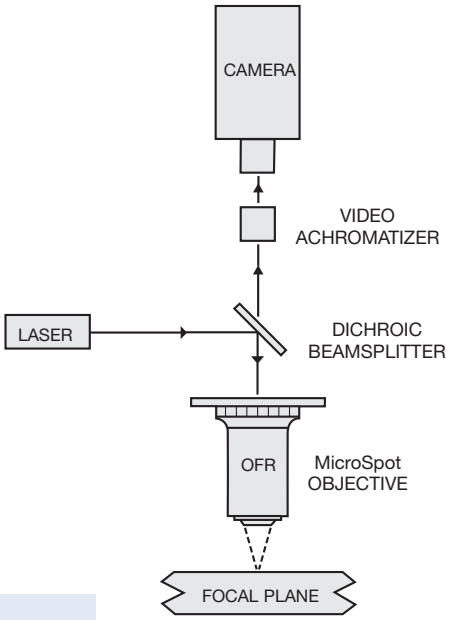
Transmit more than 60% of the visible, with maximum reflection 96-99% of the specified excimer wavelength.

Transmittance of the visible is more then 60%.

Wavelengths	
193 nm (ArF)	308 nm (XeCl)
248 nm (KrF)	351 nm (XeF)
266 nm (Nd:YAG)	354 nm (Nd:YAG)

ZERO-POWER ACHROMATIZER (Correction Triplet)
Although our LMU Objectives are achromatized for the UV, disparity between the visible (video monitoring) and UV tends to diminish the "sharpness" of the video image. This condition is corrected by our "zero-power" Achromatizer, a correction triplet that compensates for this disparity, thus producing a sharply focused video image. For this function, the Achromatizer is positioned between the camera and the beamsplitter.

Note that at this time, the Achromatizer is compatible only with LMU-3X, LMU-10X and LMU-15X.



Catalog Number	Barrel Diameter	Barrel Length	Aperture
LACU-20-λ	Inquire	Inquire	15 mm

When ordering, specify λ for AR coatings.

UV MAX REFLECTORS/DICHROIC BEAMSPLITTERS

Catalog Number	Dimensions	UV λ Reflectance*	Visible Transmittance	UV Bandwidth	Power Rating***
MYU-25-193	1" dia. x 1/4"	≥ 96%	≥ 80%	2%	300 MW/cm²
MYU-51-193	2" dia. x 1/4"	≥ 96%	≥ 80%	2%	300 MW/cm²
MYU-25-λ≥ 248	1" dia. x 1/4"	99.5%	60-80%	6%	300 MW/cm²
MYU-51-λ≥ 248	2" dia. x 1/4"	99.5%	60-80%	6%	300 MW/cm²

NOTE: When ordering, specify coating according to wavelength. For example, MYU-51-248. Reflectance shown is for random polarization. Bandwidth shown is at ±3% of peak. Power rating based upon 20 n-sec pulses, 20 Hz

YAG/VIDEO BEAMSPLITTERS
Transmission in the mid-visible more than 60% (color monitoring will appear greenish), while reflection > 99% at 1064 nm.

YAG LASER MAX REFLECTORS/DICHROIC BEAMSPLITTERS

Catalog Number	Dimensions	Reflectance*	Visible Transmittance	Bandwidth	Power Rating***
MYQ-25-532 or 1064	1" dia. x 1/4"	99.5%	> 60%	6%	500 MW/cm²
MYQ-51-532 or 1064	2" dia. x 1/4"	99.5%	> 60%	6%	500 MW/cm²

* Reflectance shown is for random polarization.
** Bandwidth shown is at ± 3% of peak.
*** Power rating based upon 20 n-sec pulses, 20 Hz.

LMM-Series Reflective Objectives

OFR MicroSpot Reflective Objectives consist of multiple reflecting elements, and therefore are achromatic. Spectral characteristics are dependent on the choice of coating. They are based on the classical Schwarzschild design. This design is corrected for third-order spherical aberration, coma and astigmatism at a specific conjugate ratio. Fifth-order aberrations are greatly reduced.

OFR MicroSpot Reflective Objectives are designed for infinite conjugate applications that require longer working distances than the provided by refractive objectives.

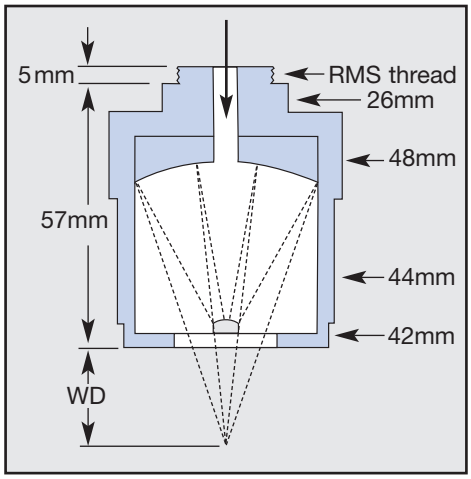
OFR MicroSpot Reflective Objectives are mounted in finely machined bodies with the universal standard, RMS thread. The convex mirror is rigidly held in place by traditional "spider vane" support.

Central Obscuration

The convex primary mirror, which acts to diverge the input laser beam, represents an obscuration in the center of the system. It is important to consider this obscuration when designing the complete imaging system. The most evident effect is a reduction of cross-sectional area in the clear aperture of the system. In consideration of a typical Gaussian beam, the obscuration can be an important factor in reducing total energy throughput. The aperture ratios listed below for each model represent the ratio of obscured to unobscured areas. Measurements are based on uniform, cross-sectional energy density.

LMM Reflective Objectives

Each Objective achieves optimum performance when the input laser beam fills its Design Aperture. Underfilling the aperture can result in decreased total transmission and can affect the focal spot diameter.



LMM-Series

MicroSpot Focusing Objectives

Catalog Number	Working Distance	Effective Focal Length	Numerical Aperture	Theoretical Focal Spot Diameter	Design Aperture	Aperture Ratio
LMM-15X-λ-MU	22 mm	13.3 mm	0.25	3 µm*	6.7 mm	21%

* Note that Theoretical Focal Spot Diameter values are based on a Gaussian profile input beam at Design Wavelength which fills the Entrance Aperture at the $1/e^2$ limits

METALLIC MIRROR COATINGS

Coating Code	Design Bandwith	Average Reflectance	Damage Threshold
-MU (Al-MgF_2	190 nm-400 nm	86%	Low Power

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