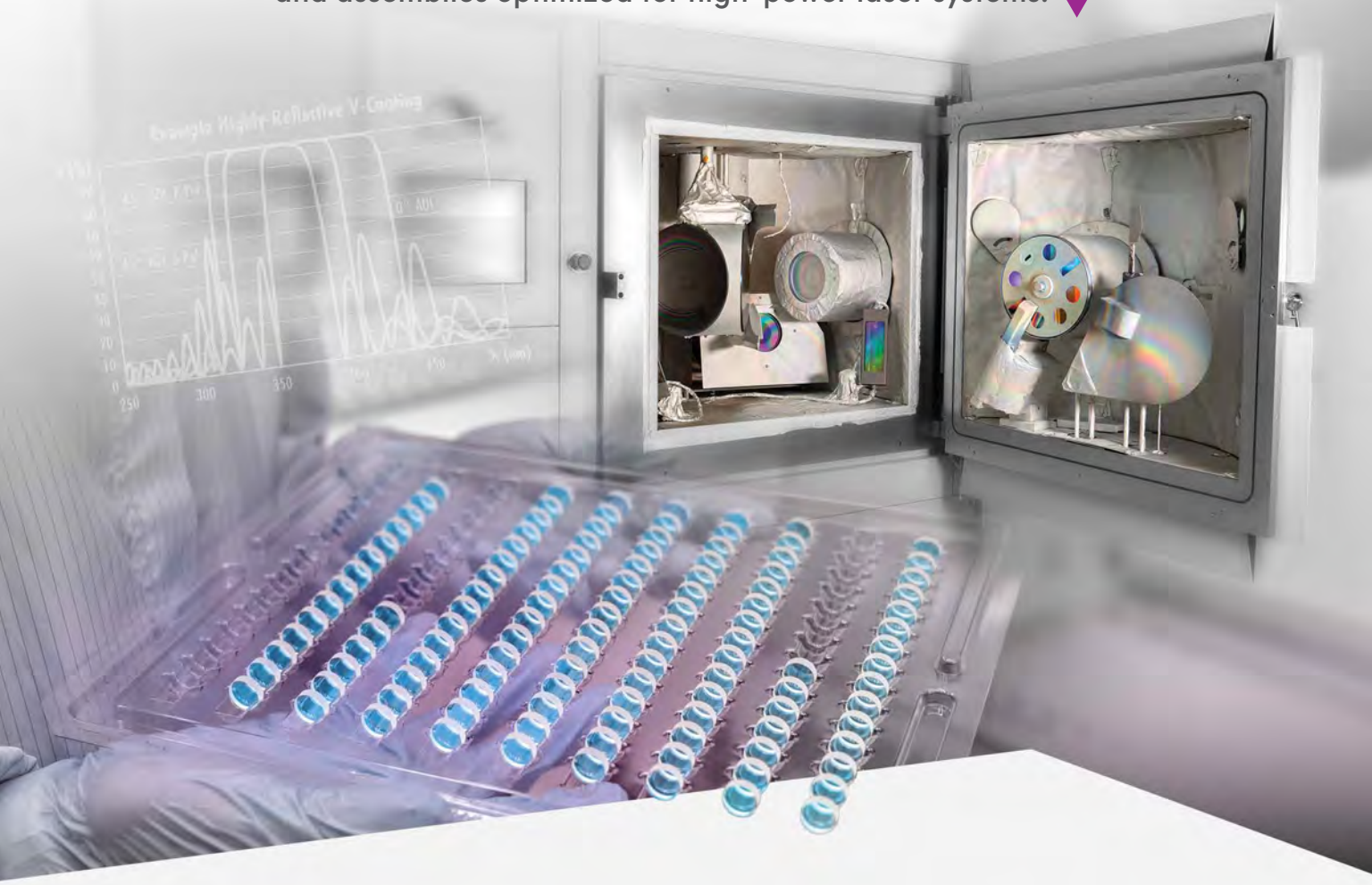
LASER OPTICS

CAPABILITIES GUIDE

Your Partner for

Custom Laser Optics Manufacturing

Edmund Optics® designs and manufactures coatings, components, and assemblies optimized for high-power laser systems.



800.363.1992
www.edmundoptics.com/LO

Edmund optics | worldwide

Custom LASER OPTICS Manufacturing

Edmund Optics® designs and manufactures laser optics coatings, components, and assemblies optimized for high-power laser systems.

Laser Coatings

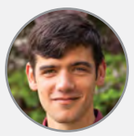
Edmund Optics® designs and deposits coatings with a high laser damage threshold (LDT) through advanced process control and monitoring of manufacturing parameters, including cleanliness and coating repeatability.

Substrate Manufacturing

Our engineers design and fabricate laser optics substrates including flats for mirrors and windows, aspheric lenses, prisms, gain elements, and more in both prototype and volume production quantities.

Assemblies

Edmund Optics® also manufactures both glass-to-glass assemblies like cube beamsplitters and metal-in-glass assemblies like beam expanders, objectives, and f-theta lenses.



Dr. Stefaan Vandendriessche
Senior Director,
Laser Optics Business Line

"We continuously put our customers first, doing this every day by **reliably manufacturing laser optics that meet our customer's specifications and needs**. Whether you need a single highly-reflective mirror coated to prototype a new laser system, or you are scaling a fully-custom laser assembly into **volume production**, our team of dedicated manufacturing and applications experts are there to **support your development, manufacturing, and assembly needs.**"

Who We Are

Edmund Optics® is here to guide you through your custom manufacturing needs.

From build-to-print manufacturing, to full custom design and manufacturing, to off-the shelf products for quick prototyping, Edmund Optics® has been offering a wide range of solutions for **30+ years**.

>200,000
Laser Optics Sold Per Year

8 Factories
US (Florida, Arizona, New Jersey), Germany, Japan, China, Malaysia, & Singapore

240+
Engineers

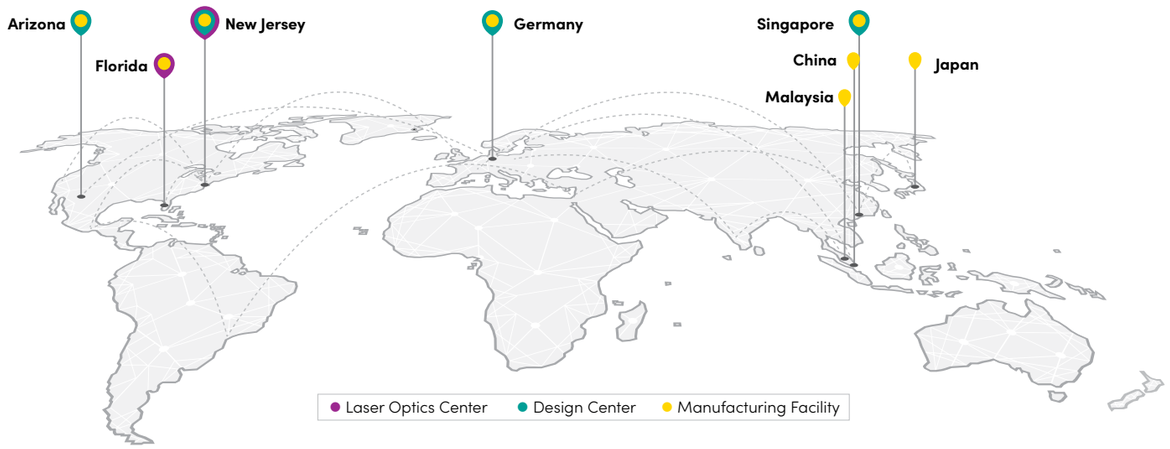
4 Design Centers
US (Arizona, New Jersey), China & Germany

1250+
Employees

2–3 Week Lead Times
for Standard Coatings

30+
Years Experience
Manufacturing High-End Laser Optics

Where We Are



Arizona, USA
Design & Manufacturing Center

21,225 sq. ft (1,972 m²) facility for advanced, high-volume laser assembly, laser optics design, and laser assembly metrology

Core Capabilities
- High-end laser optics assemblies such as beam expanders and objectives

Florida, USA
Laser Optics Manufacturing

34,000 sq. ft (3,159 m²) dedicated to manufacturing high laser damage coatings, laser crystals, and other high-precision laser optics

Core Capabilities
- Complex, multi-band highly-reflective and anti-reflective coatings
- High laser damage threshold optics
- Laser crystals

New Jersey, USA
Corporate Headquarters & Laser Damage Lab

120,000 sq. ft (11,150 m²); 20,000 sq. ft (1,860 m²) of dedicated manufacturing space. High-precision fabrication, coating, assembly, and testing cells

Core Capabilities
- Laser optics metrology
- R&D for laser optics products

Singapore

77,000 sq. ft (7,150 m²) of manufacturing space. Highly vertically-integrated facility for volume production of components such as laser-grade aspheric lenses

Core Capabilities
- Laser-grade aspheres
- Laser-grade prisms
- Optically-contacted beamsplitter cubes

Akita, Japan

80,000 sq. ft (7,430 m²) of manufacturing space. High-precision spherical lenses, prisms, and other coated optics with over 50 years of experience

Core Capabilities
- Spherical lenses
- Plano-plano laser-grade substrates

Application Expertise

Biomedical

ISO 13485 certified with decades of experience supplying medical optics from intra-cavity, to beam steering, to laser crystal and rod processing and refurbishing, to sub-assemblies such as articulating arms

In-House Expertise:
Maura Francis
Solutions Engineer II – Laser Optics

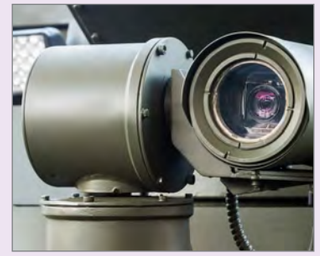
Value Proposition of Edmund Optics®:
ISO 13485 certified with decades of experience supplying medical optics from intra-cavity, to beam steering, to focus objectives, to sub-assemblies such as articulating arms

Materials Processing

Mirrors, beam expanders, and other optics with high laser damage thresholds, transparency into testing and specification development, and expertise in ultrafast applications and UV degradation

In-House Expertise:
BuKyoung Lim
Sales Engineer for Asia

Value Proposition of Edmund Optics®:
Mirrors, beam expanders, and other optics with high laser damage thresholds and transparency into testing and specification development



Security

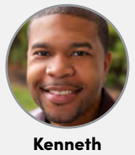
US ITAR compliant manufacturing, Technical Assistance Agreements (TAA) in place for cost-effective manufacturing in Singapore and Japan when applicable, and a one-stop shop for all of your optics

In-House Expertise:
James Karchner
Laser Optics Sales Manger

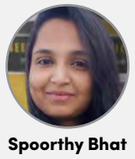
Value Proposition of Edmund Optics®:
US ITAR compliant manufacturing and Technical Assistance Agreements (TAA) in place for offshore manufacturing in Singapore and Japan when applicable

And **Much More**!

Meet our other Experts



Kenneth Barber
Senior Director of Engineering

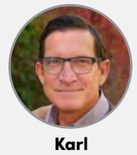


Spoorthy Bhat
Senior Product Support Engineer

Dr. Nathan Carlie
Director of Research and Development

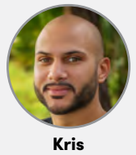
Dr. Sara Castillo
Laser Optic Sales Specialist

Dr. Matthew Dabney
Principal Engineer, Lasers



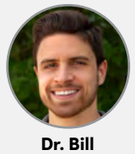
Karl George, Jr.
Senior Thin Film Engineer, Process Development

Randall Hinton
Marketplace Business Development Manager



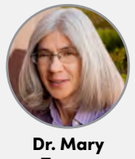
Kris McCray
Coating Supervisor

Dr. Mathias Mende
Optical Design Engineer

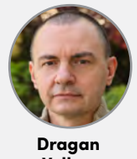


Dr. Bill Murray
Ultrafast Laser Optics Product Line Manager

Jay Small
Principal Optical Design Engineer



Dr. Mary Turner
Technical Fellow, Optical Design



Dragan Velkov
Principal Applications Engineer

Dr. Olivia Wheeler
Ultrafast Laser Optics Engineer

Laser Optics Components

- Build-to-print and fully-custom design
- Manufacturing from prototyping to volume production
- Complex coatings: high laser damage threshold, multi-band anti-reflective, highly-reflective, partially reflective, or ultrafast
- Anti-reflective coatings for wavelengths from 248nm - 12µm and highly-reflective wavelengths from 248nm - 40µm
- State-of-the-art metrology utilized to consistently meet specifications

Volume Manufacturing

- Full custom design of coatings and components
- Highly-flexible volume order servicing
- Competitive volume pricing
- Dedicated engineering support personalized for your needs

For **coating capabilities**, see pages 8-9

Flat Optics

Mirrors, windows, filters, and thin film polarizers in a wide variety of substrate materials

Flat Optic Capabilities	
Diameter:	5 - 200mm
Dimensional Tolerance:	+0/-0.010mm
Thickness:	±0.010mm
Clear Aperture:	>90%
Surface Flatness (P - V):	λ/10 to λ/20
Bevel (Face Width @ 45 Degrees):	<0.25mm
Surface Quality:	10-5
Parallelism:	<10 arcsec
Materials:	UV Grade Fused Silica (Corning HPFS® 7980), KrF Grade Fused Silica (Corning HPFS® 7980), IR Grade Fused Silica (Corning HPFS® 7979), Sapphire, N-BK7, N-SF5, N-SF11, CaF_2, and More
Surface Roughness:	10 - 15Å typical, <1Å for superpolished surfaces

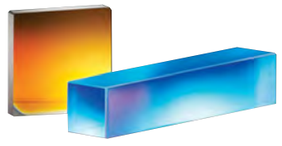
Lenses

Aspheric, spherical singlet, and achromatic lenses designed for specific laser wavelengths

Lenses Capabilities	
Diameter:	5 - 200mm
Diameter Tolerance:	+0/-0.010mm
Asphere Figure Error (P - V) @ 633nm:	1λ
Vertex Radius (Asphere):	±0.1%
Peak Slope Error:	0.35µm/mm per 1mm window
Centering (Beam Deviation):	1 arcmin
Center Thickness Tolerance:	±0.050mm
Surface Quality (Scratch Dig):	10-5
Aspheric Surface Metrology:	Profilometry (3D)
Surface Roughness (RMS):	2nm
Thickness:	±0.010mm
Power (P - V):	λ/2
Irregularity (P - V):	λ/40

Laser Crystals, Glasses, & Rods

Crystal cutting, grinding, polishing, coating for high LDT and throughput, and refurbishing



Laser Crystal Capabilities	
Dimensional Tolerance:	±0.1mm
Form Factors:	Rod, rectangular, and zigzag
Clear Aperture:	90% of Diameter
Surface Quality:	10-5
Parallelism of Polished Surfaces:	<10 arcsec
Parallelism of Tilted Ends:	<3 arcmin
Perpendicularity:	<5 arcmin
Surface Figure:	λ/10 at 632.8nm Over the Clear Aperture
Protective Chamfer:	Not to Encroach on the Clear Aperture
Materials:	**Can Fabricate, Coat, and Refurbish:** Nd:YAG, Er:YAG, CTH:YAG, Nd:YLF, Tm:YLF, Ba:YLF, Cr:LiSAF, KTP, RTP, RTA, Alexandrite, ZGP, Cr:ZnSe, Fe:ZnSe, Nd:YV04, TGG, LiNbO3, PPLN, and MgO:PPLN **Can Fabricate and Coat:** Cr:YAG, Yb:KGW, LBO, and BBO

Prisms

Wide variety of prism shapes and substrates with optical contacting available for high-power beam steering applications

Prism Capabilities	
Dimensions:	2 - 75mm
Dimensional Tolerance:	+0/-0.01mm
V-Height:	>±0.03mm
Irregularity:	λ/20
Prism Physical Angle Tolerance:	±0.5 arcsec
Max Bevel (Face Width @ 45 Degress):	±0.05mm
Surface Quality (Scratch Dig):	10-5
Bonded Prism Assembly Beam Deviation:	0.5 arcmin
Beamsplitter Cube Bonding Techniques:	Glued, air-spaced, or optically-contacted

Laser Optics Coatings

Lead times are as fast as 2 weeks for standard coatings.

Optical Coating Capabilities	
Specification	**Value**
Dimensions :	2 - 457.2mm
Clear Aperture:	Up to 100% (Dependent on Substrate Dimensions / Geometry / Tolerances)
Reflectivity:	0.05 - 99.99% (ppm-level losses on request)
Anti-Reflective Wavelength Range:	248nm - 12µm
Highly-Reflective Wavelength Range:	248nm - 40µm
Laser Damage Threshold (LDT) for ns pulses:	>40 J/cm² @ 1064nm, 20ns, 20Hz Pulses
Laser Damage Threshold (LDT) for ultrafast fs pulses:	>0.3J/cm² @ 800nm, 48fs, 100Hz Pulses >0.7 J/cm² @ 800nm, 200fs, 100Hz >0.4 J/cm² @ 1030nm, 200fs, 100Hz >0.9 J/cm² @ 1030nm, 500fs, 100Hz
Group Delay Dispersion (GDD) Range:	-4000 - 5000 fs²
Durability:	MIL-PRF-13830B APP C, PARA C.3.8.4, PARA C.3.8.5, MIL-C-48497A
Shortpass Filter Cut-Off Wavelength:	400 - 1600nm
Longpass Filter Cut-On Wavelength:	240 - 7300nm
Bandpass Filter CWL, OD, and Bandwidth:	193 - 10,600nm, >OD 7 in Blocking Range, 1nm - Broadband
Notch Filter CWL:	355 - 1550nm
Reflective ND Filter OD:	OD 0.1 - OD 3
Filter Center Wavelength (CWL) Tolerance:	±1nm
Filter Edge Tolerance:	<1% Deviation, <0.2% Special Cases
Beamsplitter (BS) Wavelength Range:	240 - 20,000nm
BS Polarization Extinction Ratio (S:P):	10,000:1

Coating Technologies

Edmund Optics® engineers have the expertise to guide you through selecting the best coating technology for your application.

Electron-Beam (E-Beam) Coatings
- Low-stress, cost-effective coatings ideal for many laser optics

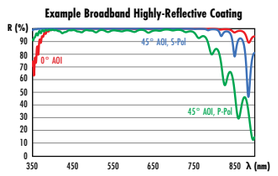
Ion-Assisted Deposition (IAD) E-Beam Coatings
- Versatile coating technology achieving higher density and more environmentally stable coatings

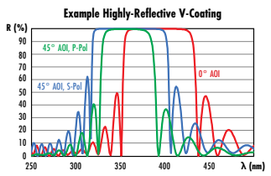
Ion Beam Sputtered (IBS) Coatings
- Highly-repeatable, highly-environmentally-stable technology ideal for high reflectivities, ultrafast optics, and filters with sharp transitions

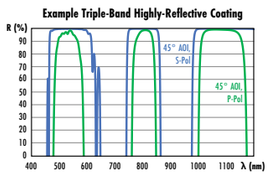
Magnetron Sputtering
- Low chamber pressure reduces setup time and allows for more economical coating of high-volume optics

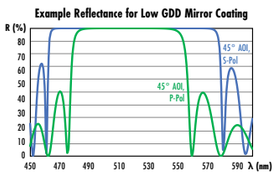
Sample Coating Curves

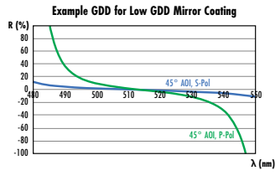
These coating curves are not an exhaustive summary of capabilities, but they show some examples of the coatings designed by Edmund Optics®.

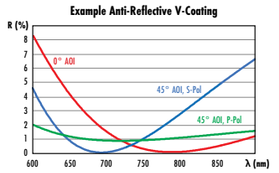


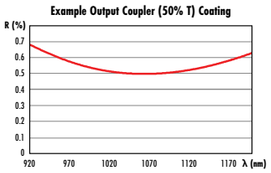












Key Technologies

Ion Beam Sputtering

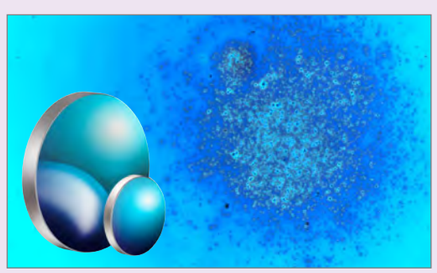
- Reflectivities >99.99% (ppm-level losses on request)
- Coatings that are more environmentally stable in varying temperature and humidity conditions
- Coatings covering wavelengths between 355 – 1600nm
- Group delay dispersion (GDD) control for ultrafast coatings

Superpolishing

- Minimize scatter losses with ultra-low surface roughness
- Fused silica with RMS surface roughness <1Å
- Standard sizes and shapes from 12.7 to 50.8mm
- Custom sizes and shapes upon request
- Supported by a suite of in-house metrology
- Parts-per-million level scattering

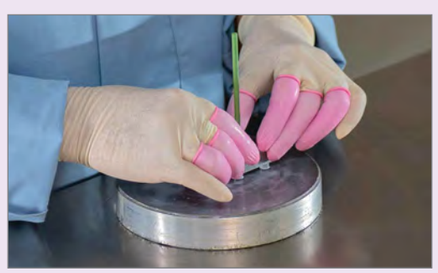
Ultraviolet (UV) Degradation

- In-house laser lab performing long-run applied UV laser exposure experiments at 355nm with a 10ns pulse duration
- Laser-induced contamination is a key concern for UV laser systems
- Contamination resulting from the environment or outgassing can significantly reduce performance or lead to system failure
- Intimate knowledge of cleaning and assembly techniques to mitigate these effects



Laser Crystal & Glass Processing

- Laser crystal and doped glass grinding, polishing, and coating in sizes from 2 – 457.2nm
- Over 30 years' experience with coating adhesion and durability for laser optics
- Also refurbish both flat and curved laser rods, preventing you from waiting to source whole new rods
- Our metrology lets us guarantee centration and radius of curvature



Ultrafast Laser Optics

- Ultrafast pulses have inherently broad bandwidths, making controlling chromatic dispersion critical
- Group delay dispersion (GDD) of ultrafast optics must be finely controlled
- Edmund Optics® designs and deposits ultrafast coatings with GDD values from -4,000 – 5,000 fs^2
- Dielectric highly-reflective and anti-reflective coatings as well as ultrafast-enhanced silver coatings

Design and Manufacturing Capabilities

- Highly-dispersive mirrors, low GDD optics, and beam expanders
- Intra- and extra-cavity optics for high-power ultrafast lasers
- 3rd order dispersion of 0 fs^3, or negative values down to -2500 fs^3
- Cost-effective ultrafast-enhanced silver coatings with R>99% and GDD as low as 0 ±20 fs^2 over common ultrafast wavelengths

Ultrafast Metrology

- Accurately measure GDD of multilayer ultrafast optics
- Ultra-broadband spectral coverage ranging from 250nm to 2100nm
- GDD accuracy of ±5 fs^2 at angles of incidence between 0 – 70°

Technical Expertise

- In-house experts with years of ultrafast optics manufacturing and ultrafast laser applications experience
- Guidance in understanding what GDD, 3rd order dispersion, and other specifications are needed
- Partnership with UltraFast Innovations for developing cutting-edge ultrafast coatings

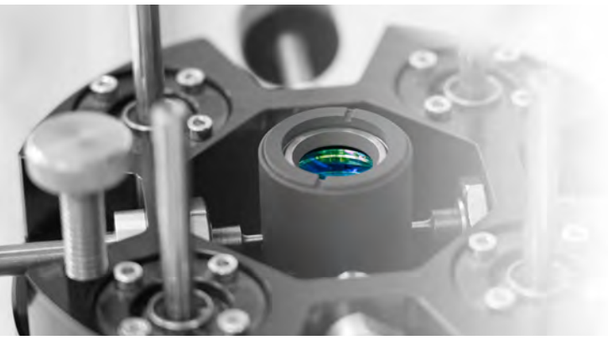
Award-Winning LDT

- Our PeakPower High LDT Low GDD Ultrafast Mirrors won the Platinum-Level 2024 Laser Focus World Innovators Award
- They have the highest available laser damage threshold (LDT) for thin film coatings designed for 920nm ultrafast lasers
- LDT values exceeding 0.75J/cm^2 for 25fs pulse durations at 920nm

Laser Optics Assemblies

- Design and manufacturing capabilities for custom beam expanders, focusing objectives, f-theta lenses, and other laser optics subassemblies
- Active alignment and centration for advanced assemblies
- High-power assemblies designed without internally-focusing ghost reflections
- Full assembly development from modeling physical optics propagation, to designing lens elements, to coating, to assembly, to testing

Beam Expander Capabilities	
Expansion Power:	>1X - 20X
Design Wavelengths:	Common Laser Lines Including Nd:YAG, Yb:YAG, Ti:sapphire, and Tm/Ho-Doped Fiber Lasers, Broadband
Mounts:	C-Mount, M22, M30, Custom
Beam Adjustment Mechanisms Available:	Sliding Optics, Rotating Optics, Fixed
Testing/Design Specifications:	Transmitted Wavefront Error, Power in the Bucket / Energy on Target, Focused Spot Size
Assembly Size:	>20mm - >1m
Ruggedization Available:	Athermalization, Shock and Vibration, Sealing from Contaminants



Advanced Laser Assemblies

- Actively compensate for the decenter and tilt of optical components during assembly
- Critical for precision objectives, beam expanders, f-theta lenses, and other assemblies
- 4 ISO Class 6 clean rooms for assembly and a Class 7 cleanroom for incoming inspection

Metrology for Laser Optics Assemblies

- In-house testing to measure assembly performance
- Transmitted wavefront error, laser beam profiling, and beam caustics
- Development of application-specific tests

Beam Expander Parameters We Can Measure	
Transmitted Wavefront Error (TWE):	How much light deviates from its ideal shape after passing through the assembly
M^2 Factor:	For an ideal Gaussian input beam, compare the assembly output to that ideal input beam
Power in the Bucket (PIB):	How much laser power is integrated over a specified "bucket", most often a spot of a specific radius at the target
Beam Parameter Product (BPP):	Quantifies how well the output beam can be focused down to a spot
Focused Spot Size:	The size of the beam focused to a spot after the assembly based on a certain laser's operating parameters
Beam Deviation:	Also called beam wander, this characterizes how off-axis the output beam is
Transmitted Power:	How much input laser power makes it through the assembly without being lost
Input / Exiting Beam Waist Diameter:	The smallest diameter along the beam path

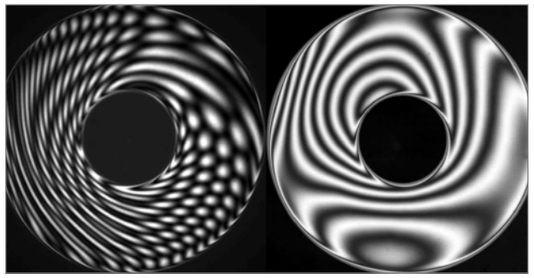
Equipment

- Gentec-EO Beamage-M2 Beam Profiler
- DataRay Beam'R2 Beam Profiler
- Phasics SID4-UHR Wavefront Sensor
- Ophir 3A-P-Quad Laser Position Sensor
- Ophir PD300R-UV Photodiode Sensor
- Juno USB Virtual Laser Power & Energy Meter
- Cobolt Rumba 1064nm Fiber-Coupled Laser
- Cobolt 08-DPL 532nm Fiber-Coupled Laser
- And more!

Metrology

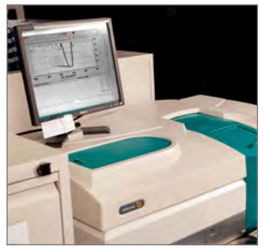
Laser Optics Assembly Metrology

- In-house testing to measure assembly performance
- Transmitted wavefront error
- Laser beam profiling
- Measuring power in bucket and energy on target
- Development of application-specific tests



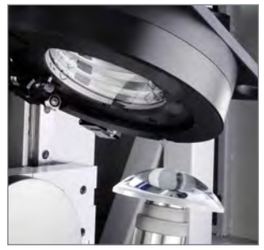
Short Coherence Length Interferometry

- Special LED source used to measure parallel, flat surfaces while minimizing reflections off back surfaces
- Eliminates the need for special treatment of the rear surface, which minimizes measurement time, the risk of damage to the part, and the risk of inaccurate measurements
- Ideal for measuring dual-side-coated optics such as IBS coated mirrors with stress-compensating coatings on the backside



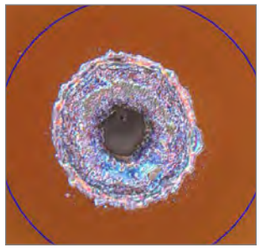
Spectrophotometry

- Used to characterize reflective and transmissive spectral performance
- Large spectral measurement range of 120nm - 20µm
- Measures greater than OD 7 blocking for an accurate representation of transmission and rejection bands



Interferometry

- Transmitted and reflected wavefront measurements down to <λ/20
- Stitching, large and small aperture, and computer-generated hologram setups
- Used to qualify surface irregularity of flats, spherical and aspherical components, and optical assemblies



Laser Damage Threshold (LDT) Testing*

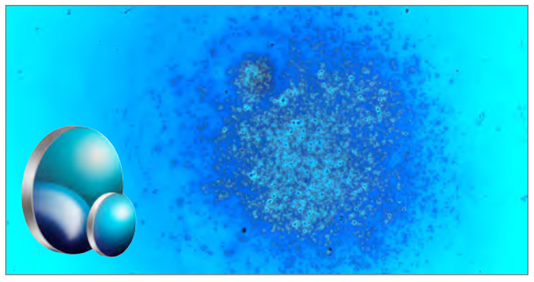
- Components tested both in-house and outsourced for guaranteed LDT
- Internal high-power nanosecond Nd:YAG laser at 1064nm and harmonics (532nm and 355nm)
- Other wavelengths and pulse durations available

Cavity Ring-Down Spectroscopy

- High-accuracy loss measurement with sensitivity in the parts per million
- Tuned for common Nd:YAG harmonics - other wavelengths available upon request
- Accurately quantifies both high and low reflectivity laser optics

Photothermal Common-Path Interferometry

- Accurately measure absorption for better characterization of the spectral properties of optical coatings and substrates
- A pump-probe geometry measures change in refractive index due to absorption-induced thermal expansion
- More sensitive and accurate absorption measurement for very low levels of absorption than spectrophotometers, which determine absorption indirectly by directly measuring transmission



Ultraviolet (UV) Degradation

- In-house laser lab performing long-run applied UV laser exposure experiments
- Laser-induced contamination is a key concern for UV laser systems
- Contamination resulting from the environment or outgassing can significantly reduce performance or lead to system failure
- Intimate knowledge of cleaning and assembly techniques to mitigate these effects

Differential Interference Contrast (DIC) Microscopy

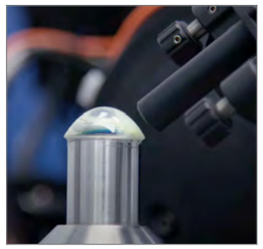
- High-sensitivity defect detection in transmissive materials
- Used for analyzing laser damage in optical coatings and substrates
- Surfaces analyzed under 100X magnification

Ultrafast Dispersion Characterization

- Accurately measure group delay dispersion (GDD) of multilayer ultrafast optics
- Ultra-broadband spectral coverage ranging from 250nm to 2100nm
- GDD accuracy of ±5 fs^2 at AOI between 0 - 70°

Atomic Force Microscopy (AFM)

- High-accuracy characterizations of surface roughness and feature sizes and locations
- Lateral resolution down to 3nm
- Vertical resolution down to 0.1nm



Non-Contact 3D Profilometry

- Verify surface profile of precision aspheric lenses
- OptiPro UltraSurf 4X 100 Non-Contact
- Measure surfaces without scratching or damaging the parts

**Test data available upon request*

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