Edmund optics | worldwide

LASER OPTICS

NEW Dedicated Laser Optics

Manufacturing Center

▼ **34,000 sq. ft** of **coatings**, **components**, and **assembly capabilities**

800.363.1992 | www.edmundoptics.com/**LO**

Laser Optics Manufacturing – From Prototype to Production

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

Optical Coatings

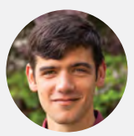
Edmund Optics® designs and deposits coatings with a high laser damage threshold (LDT) through advanced process control and monitoring of manufacturing parameters, including cleanliness and coating repeatability.

Custom Manufacturing

Our engineers design and fabricate custom laser optics including mirrors, crystals, lenses, filters, polarizers, prisms, beamsplitters, beam expanders, aspheric lenses, focusing objectives, and more in both prototype and volume production quantities.

High Laser Damage Thresholds

Edmund Optics® has over 30 years' experience producing high LDT optics. An in-house laser testing lab allows for internal process improvement and verification of laser damage threshold. Ultraviolet, visible, infrared, and ultrafast laser sources are employed to test optics in a wide range of use cases.



Dr. Stefaan Vandendriessche
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

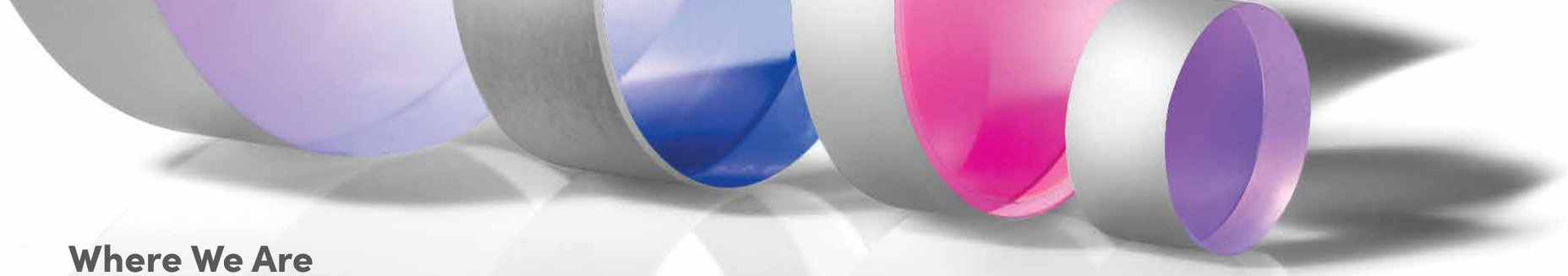
240+
Engineers

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

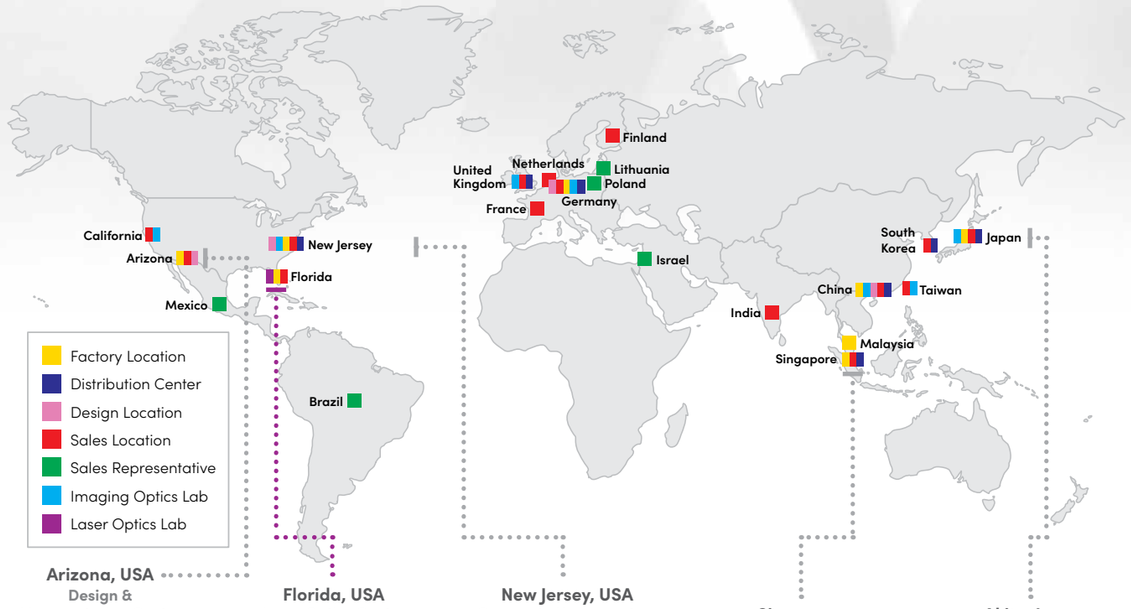
1250+
Employees

35+
Trade Shows & Virtual Events
Exhibits Per Year

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 Center

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

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

Meet our other Experts

Kenneth Barber
Senior Director of Engineering

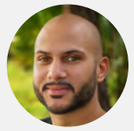
Dr. Nathan Carlie
Director of Research and Development

Dr. Sara Castillo
Laser Optic Sales Specialist

Dr. Matthew Dabney
Principal Engineer, Lasers

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

James Karchner
Laser Optics Sales Manager



Kris McCray
Coating Supervisor

Application Expertise

In-House Expertise:
Randall Hinton
Business Development Manager, Life Sciences

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

Biomedical Lasers

- Aesthetic lasers for skin treatments, hair removal, and tattoo removal
- Eye surgery lasers for corrective vision procedures like LASIK
- Ultrafast microscopy and a wide variety of clinical procedures

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

Materials Processing

- Welding with low thermal distortion, high speeds, and small focused spots
- Complex cuts and contours for a wide variety of materials
- Marking, engraving, surface treatments, ultrafast materials processing, and 3D printing

In-House Expertise:
Maura Francis
Solutions Engineer II

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

Security, Communications, and Defense Systems

- Laser designators and rangefinders requiring high LDT
- High-energy laser (HEL) directed energy systems
- Laser-based free-space optical (FSO) communications for secure transmissions

And **Much More**!

Dr. Mathias Mende
Optical Design Engineer

Dr. Bill Murray
Ultrafast Laser Optics Product Line Manager

Deepthi Sasikumar
Technical Engineering Manager

Jay Small
Principal Optical Design Engineer

Dr. Mary Turner
Technical Fellow, Optical Design

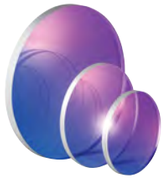
Dragan Velkov
Principal Applications Engineer

Dr. Olivia Wheeler
Ultrafast Laser Optics Engineer

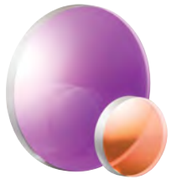
Laser Optics Components

- 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, or partially-reflective
- Anti-reflective coatings for wavelengths from 248nm - 12µm and highly-reflective wavelengths from 248nm to 40µm
- State-of-the-art metrology utilized to consistently meet specifications

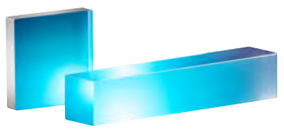
Laser Mirrors



Laser Windows

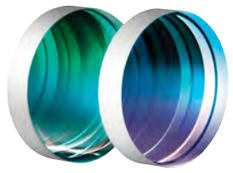


Laser Lenses



Laser Crystals

Laser Filters



Laser Beamsplitters

Laser Prisms

Laser Polarizers

Flat Optics

Mirrors, windows, filters, and 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

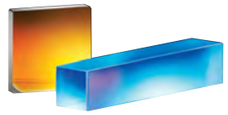
Lenses

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

Lenses Capabilities	
Diameter:	5 - 200mm
Diameter Tolerance:	+0/-0.010mm - +0/-0.025mm
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

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:	<30 arcmin
Surface Figure:	λ/8 at 632.8nm Over the Clear Aperture
Protective Chamfer:	Not to Encroach on the Clear Aperture
Materials:	YAG, YLF, YALO, KTP, LBO, BBO, YVO_4, PPSLT, PPLN, and Phosphate-Doped Glasses

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:	45° & 90° ±0.5 arcsec
Penta Prism Deviation:	±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

For **coating capabilities**, see page 8

Laser Optics Coatings

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-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

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, Guaranteed
Laser Damage Threshold (LDT) for ultrafast fs pulses:	>0.3J/cm² @ 800nm, 48fs, 100Hz Pulses, Guaranteed >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

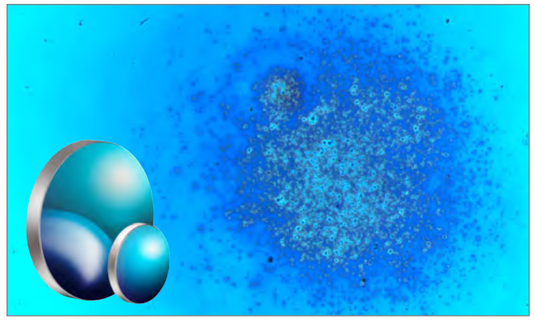
Key Technologies

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

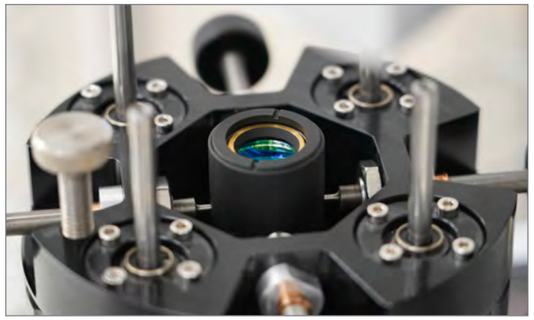
Superpolishing

- Minimize scatter losses with ultra-low surface roughness
- 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



UV Fatigue and Laser-Induced Contamination

- 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



Advanced Laser Assemblies

- Supported in-house testing for transmitted wavefront error, power in the bucket, energy on target, and focused spot size
- Actively compensate for the decenter and tilt of optical components during assembly
- Critical for precision objectives, beam expanders, and other assemblies
- 4 ISO Class 6 clean rooms for assembly and a Class 7 cleanroom for incoming inspection

Ultrafast Laser Optics

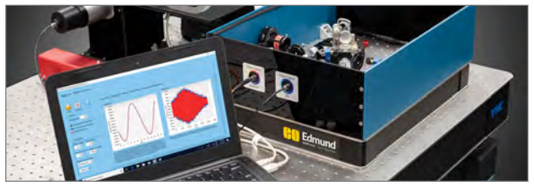
- Ultrafast pulses have inherently broad bandwidths, making controlling chromatic dispersion critical
- Group delay dispersion (GDD) of ultrafast optics must be finely controlled
- Edmund Optics® designs and deposits ultrafast coatings with GDD values from -4,000 - 5,000 fs^2
- Dielectric highly-reflective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

Laser Optics Assemblies

- Design and manufacturing capabilities for custom beam expanders, focusing objectives, 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

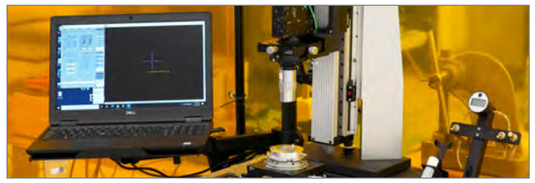
Manufacturing Capabilities

- 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°



Assembly Expertise

- Transfer from concept to volume manufacturing
- Expedited prototyping
- Cleanroom assembly
- Active alignment and centration
- Testing and certification

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

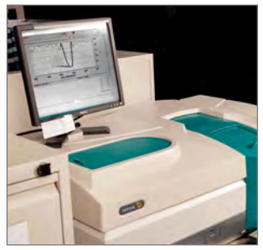
Technical Expertise

- 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

Assembly Metrology

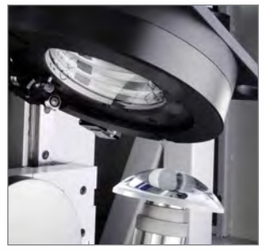
- In-house testing to measure assembly performance
- Transmitted wavefront error, laser beam profiling, and beam caustics
- Measuring power in bucket and energy on target
- Development of application-specific tests

Metrology



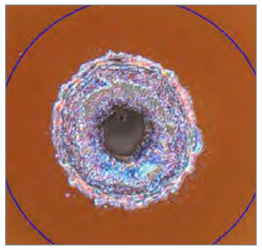
Spectrophotometry

- 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*

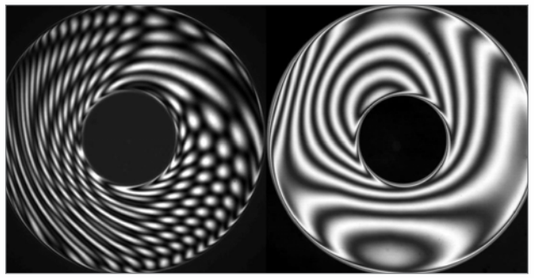
- Components tested both in-house and outsourced for guaranteed LDT
- Internal high-power nanosecond Nd:YAG laser at 1064nm and harmonics (532nm and 355nm)
- Other wavelengths and pulse durations available

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

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

Differential Interference Contrast (DIC) Microscopy

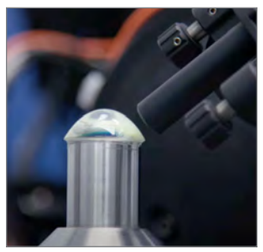
- High-sensitivity defect detection in transmissive materials
- Used for analyzing laser damage in optical coatings and substrates
- Surfaces analyzed under 100X magnification

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



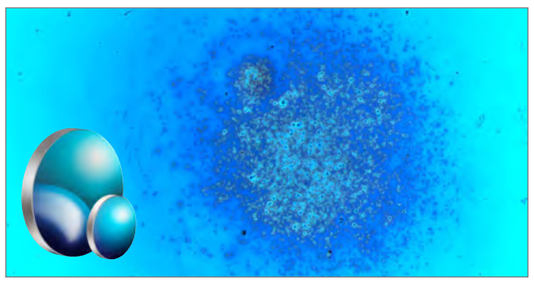
Non-Contact 3D Profilometry

- 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*

Photothermal Common-Path Interferometry

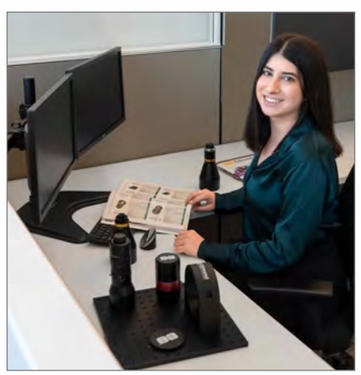
- Accurately measure absorption for better characterization of the spectral properties of optical coatings and substrates
- A pump-probe geometry measures change in refractive index due to absorption-induced thermal expansion
- More sensitive and accurate absorption measurement for very low levels of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



UV Fatigue and Laser-Induced Contamination Testing

- 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

Process Flow – From Quote to Product Delivery



① Inquiry

- Customer reaches out to discuss their technical needs and current issue
- Possibilities include coat only, complete product, build-to-print fully-custom design, or modifications to existing designs or products
- Primary specifications, compliance information, and the expected schedule are determined
- For this process flow, we will follow the steps for sourcing a fully-custom laser beam expander designed for a customer's application-specific needs

② Feasibility Stage

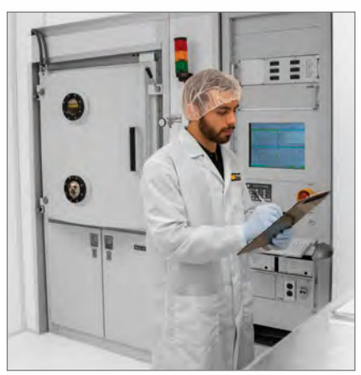
- Advanced Laser Applications team determines application-specific require-ments
- Initial design and trade-off review done to evaluate potential technical solutions
- Investigate if customizing off-the-shelf product is feasible to reduce lead times or whether a completely-custom design is required
- A quotation could be included at this stage

③ Design for Manufacturability

- A detailed optical and optomechanical design is created that builds off of the foundation created in the feasibility study
- A full tolerancing analysis determines yield expectations
- Design is optimized for manufacturability
- Designs are completed for all components, coatings, and metal housing needed

④ Manufacturing

- All individual glass components are ground, polished, and coated
- Metal optomechanical housing is machined and the full beam expander is assembled
- Active alignment and other advanced assembly techniques employed when needed
- In-process metrology such as interferometry, spectrophotometry, and beam caustic measurements done to verify specifications



⑤ Testing

- The full assembly is tested to verify all specifications are met
- Application-specific test beds developed when necessary
- Testing available for transmitted wavefront error, beam profile, beam caustics, and energy on target at various laser wavelengths
- Environmental testing for shock and vibration, water exposure, and temperature swings also available

⑥ Delivery

- Initial prototypes delivered, comprehensive first article inspection reports (FAIRs) for product qualification
- Highly-flexible volume order servicing including support for blanket orders with scheduled releases
- Competitive volume discounts
- Continued dedicated engineering support to ensure project success

Edmund optics | worldwide

101 E. Gloucester Pike | P.O. Box 9000 | Barrington, NJ 08007 USA

PRSRT STD
US POSTAGE
PAID
EDMUND OPTICS, INC

♦ REFERENCE NUMBER

♦ CUSTOMER NUMBER

The **Future** Depends on Optics®

240+ Global Engineers with expertise in a **wide variety of applications**

Custom laser optics manufacturing projects from Edmund Optics® are supported by a dedicated sales team, design group, and project management team. They can support your project from concept, to design, to quoting, order placement, and order fulfillment. You will consistently have the same points of contact who are knowledgeable in your specific application.

800.363.1992 | www.edmundoptics.com/**LO**