

# CAPABILITIES GUIDE

CUSTOM MANUFACTURING from PROTOTYPE to PRODUCTION

Global Design & Manufacturing Facilities

page 3

Manufacturing Capabilities for Custom & Off-the-Shelf Optics

pages 4-15

Design, Rapid Prototyping, Volume Support & Other Services

pages 16-22

Contact us for a Standard or Custom Quote Today!

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 **Edmund**  
optics | worldwide

[www.edmundmanufacturing.com](http://www.edmundmanufacturing.com)



**24-HOUR  
TECHNICAL PHONE SUPPORT**  
800.363.1992 or 856.547.3488  
Sunday, 8PM - Saturday, 8PM ET

## WHO IS EDMUND OPTICS®?

The Future Depends on Optics® and the world-changing innovations they enable. Edmund Optics® (EO) has contributed to this innovation by manufacturing and supplying industries across the globe with precision optical components and subassemblies for more than **80 years**.

Whether you need off-the-shelf optics for rapid prototyping or cost-effective custom components for volume production, we have the capabilities and engineering expertise to meet your specifications, timelines, and budgets. Our engineers create tailored solutions for unique optical challenges through expert application support, both build-to-print and completely-custom design, and a world-class quality and metrology program. Every step of the way, Edmund Optics® is committed to ensuring product and procedural quality.

We are a family-owned business with over 1,200 employees in 12 countries around the world, and we look forward to working with you!



Warm regards,

*Marisa A. Edmund*

Marisa Edmund, Chief Marketing & Sales Officer & 3<sup>rd</sup> generation owner

### Contact Us for Confidential Application Support!

- Phone, Email, and Online Chat Contact Methods – Get Engineering Assistance Your Way!
- 24/6 LiveChat Support Sunday 8:00PM – Saturday 8:00PM, EST
- Quick Non-Disclosure Agreement (NDA) and Confidential Disclosure Agreement (CDA) Process

### Leverage the Wealth of Technical Content on our Website!

- Over 157,000 Downloadable Documents and Drawings
  - 2D & 3D Drawings
  - Prescription Files
  - Coating Curves and More!
- Over 1,400 videos, Tech Tools, Application Notes, Articles, and FAQs in Our Online Knowledge Center

## WHY EDMUND OPTICS®?

With over **80 years in business** and **8 global manufacturing facilities**, EO's promise to customers is:

**MORE OPTICS, MORE TECHNOLOGY,  
AND MORE SERVICE.**

### Optical Manufacturing

- Custom and volume manufacturer of quality optical and imaging products

### Engineering Services

- Provider of prototyping services, optical consulting, and design

### Marketplace

- One-stop-shop for the best brands and products in optics and photonics

**VOTED #1  
PREFERRED SUPPLIER**  
of optical components

13 years in a row.

Also ranked best in industry  
**Technical Support | Product Variety**  
**Customer Service | Competitive Pricing**  
**Lead Times | Product Performance**

– October 2020 Readex Research Survey

## GLOBAL MANUFACTURING FACILITIES

Edmund Optics® manufactures and supplies customers around the globe with millions of precision optical components and optical assemblies. Whether stock, modified standard, or custom, we have the expertise and resources necessary to manufacture optical products based on your project's specific requirements. Our dedicated and skilled team members will ensure that you receive the optimal solution for your application, while our quality assurance teams guarantee the best final products. In the last few years, we have added three new global manufacturing facilities.



**SCAN HERE**  
to watch a video about our  
key manufacturing facilities.



## GLOBAL DESIGN & MANUFACTURING

**Arizona, USA**

**New Jersey, USA**

**Florida, USA**

**Germany**

**China**

**Japan**

**Singapore**

**Malaysia**

**Arizona, USA**  
Tucson Design & Manufacturing Centers  
21,225 sq. ft. (1,972 m<sup>2</sup>) of combined facilities for advanced, high-volume assembly of optical systems, along with a separate Tucson design center

**Florida, USA**  
34,000 sq. ft. (3,159 m<sup>2</sup>) facility manufacturing high laser damage coatings, laser crystals, and other high-precision laser optics

**New Jersey, USA**  
Corporate Headquarters  
120,000 sq. ft. (11,150 m<sup>2</sup>); 20,000 sq. ft. (1,860 m<sup>2</sup>) of dedicated manufacturing space. High precision fabrication, coating, assembly, and testing cells

**Mainz, Germany**  
EO Germany Design & Manufacturing  
7,060 sq. ft. (660 m<sup>2</sup>) European manufacturing base for polarizers and colored filter glass and home for European Optical Design service

**Singapore**  
77,000 sq. ft. (7,150 m<sup>2</sup>) of manufacturing space. Highly vertically integrated facility for volume production of spherical and aspheric lenses, prisms, and other coated and mounted optics

**Malaysia**  
16,140 sq. ft. (1,500 m<sup>2</sup>) of manufacturing space. Supports Singapore facility in volume production of spherical lenses and prisms

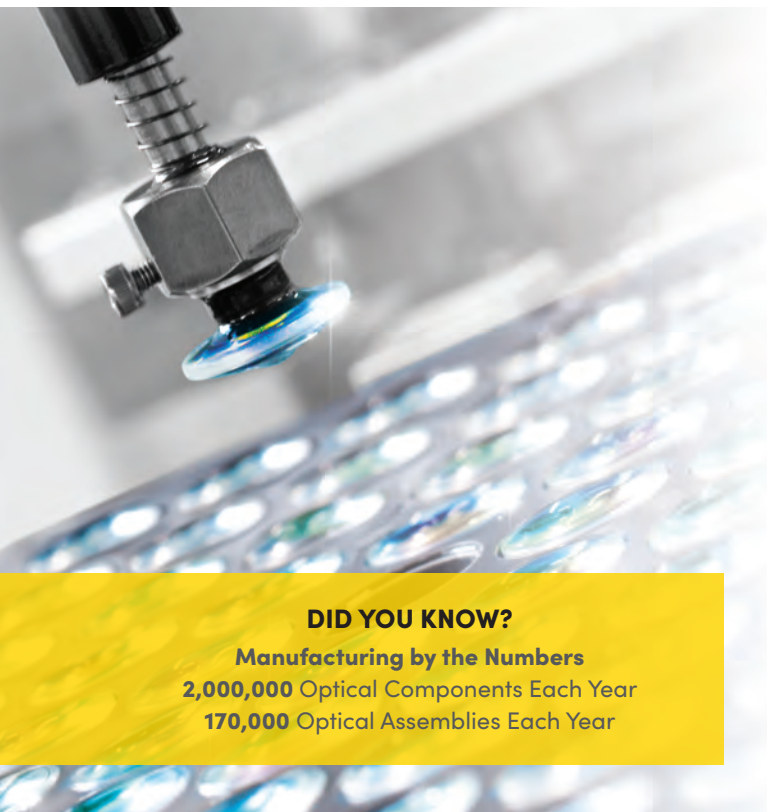
**Akita, Japan**  
80,000 sq. ft. (7,430 m<sup>2</sup>) of manufacturing space. High precision spherical lenses, prisms, and other coated optics with over 50 years of experience

**Shenzhen, China**  
16,140 sq. ft. (1,500 m<sup>2</sup>) of manufacturing space. On-site design, assembly, and testing of high volume optomechanical and imaging assemblies

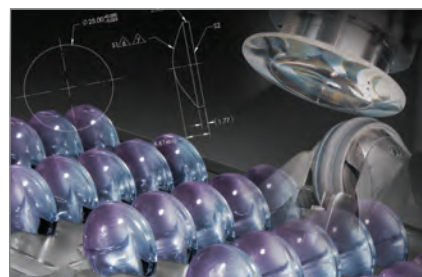
For more detailed **MANUFACTURING CAPABILITIES**, visit [www.edmundoptics.com/manufacturing](http://www.edmundoptics.com/manufacturing)

**OVERVIEW  
OF MANUFACTURING  
CAPABILITIES**

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**DID YOU KNOW?**  
**Manufacturing by the Numbers**  
**2,000,000** Optical Components Each Year  
**170,000** Optical Assemblies Each Year



**CUSTOM COMPONENTS**

Edmund Optics® takes customers from prototype to volume production and specialize in creating cost-effective solutions that meet their specifications, timelines, and budgets.

- Lenses, Mirrors, Prisms, Beamsplitters, Filters, and More
- Build-to-Print Manufacturing
- Competitive Volume Pricing
- Global Manufacturing Facilities



**CUSTOM ASSEMBLIES**

The expert team of Edmund Optics® optical and optomechanical designers, project managers, and manufacturing engineers create a wide variety of different types of optomechanical assemblies.

- Imaging Lenses, Laser Beam Expanders, Microscope Objectives, and More
- Environmental Ruggedization for Shock & Vibration, Moisture, and Athermalization
- Global Assembly Facilities



**QUALITY CONTROL  
AND METROLOGY**

Every step of the way, Edmund Optics® is committed to ensuring product and procedural quality and has a proven track record of tailored testing for optical assemblies customized to project requirements.

- State-of-the-Art In-Process Metrology And Quality Management
- ISO 9001 Certified and ISO 10110 Compliant with MIL-SPEC Quality Programs
- Thorough Preventative and Corrective Action Procedures

**POLISHED ASPHERIC LENSES**

- Manufacturing in US and Singapore
- Stock and Custom, from Design and Prototype to Volume Production
- Build-to-Print Capabilities
- Over 700 Aspheric Lens Designs Available for Delivery
- MRF Fine Finishing Consistently Exceeding  $\lambda/40$  Surface Accuracy and State-of-the-Art Metrology

Edmund Optics® is a recognized leader in aspheric lens manufacturing, with extensive experience producing polished aspheres for a broad variety of applications ranging from life science systems such as ophthalmic instruments and surgical devices, to industrial laser equipment, to metrology and analytical instruments, to defense applications. Edmund Optics® high volume aspheric lens manufacturing cell operates 24 hours a day to produce thousands of precision aspheric lenses per month. Our manufacturing cells feature state-of-the-art production and metrology equipment, which complements our expert knowledge in aspheric lens design and manufacturing.

Whether your application calls for a standard component from our vast inventory, a build-to-print lens, or a fully customized design effort, our expert optical design and manufacturing engineers can develop solutions to meet your needs.



**SCAN HERE**  
 to watch a video about how  
**aspheric lenses are made.**



Aspheric Manufacturing Capabilities			<small>*<math>\lambda/10</math> wave at 632.8nm, limited by design and/or metrology</small>
	Commercial	Precision	High Precision
<b>Diameter:</b>	10 - 200mm	10 - 200mm	10 - 150mm
<b>Diameter Tolerance:</b>	+0/-0.100mm	+0/-0.025	+0/-0.010
<b>Asphere Figure Error (P - V):</b>	3 $\mu$ m	1 $\mu$ m	<0.06 $\mu$ m
<b>Sag:</b>	25mm max	25mm max	25mm max
<b>Typical Slope Error:</b>	1 $\mu$ m per 1mm window	0.35 $\mu$ m per 1mm window	0.15 $\mu$ m per 1mm window
<b>Centering (Beam Deviation):</b>	3 arcmin	1 arcmin	0.5 arcmin
<b>Center Thickness Tolerance:</b>	$\pm$ 0.100mm	$\pm$ 0.050mm	$\pm$ 0.010mm
<b>Surface Quality (Scratch Dig):</b>	80-50	40-20	10-5
<b>Aspheric Surface Metrology:</b>	Profilometry (2D)	Profilometry (2D & 3D)	Interferometry

**MANUFACTURING EQUIPMENT**

- 5-Axis CNC Grinding Machines
- 5-Axis CNC Polishing Machines
- QED MRF Finishing Machines for Fine Finishing
- Centering Machines

**METROLOGY**

- Talysurf PGI 1240 Profilometers
- QED ASI™ Aspheric Stitching Interferometers
- Zygo® NewView White Light Interferometers
- OptiPro UltraSurf 4X 100 Non-Contact Profilometers
- TRIOPTICS Opticentric® Centration Measurement Machines
- Zeiss Contura G2 CMMs
- Design-Specific Computer Generated Holograms (CGH)
- LUPHOScan 260 HD

For more information on **ASPHERIC LENSES**, visit [www.edmundoptics.com/capabilities/aspheric-manufacturing](http://www.edmundoptics.com/capabilities/aspheric-manufacturing)

SPHERICAL LENSES



- Manufacturing Redundancy in Multiple Factories Across US, Singapore, and Japan
- Prototype Through High Volume Production Capabilities
- Large Variety of SCHOTT, Ohara, and CDGM Glass Types in Stock
- Build-to-Print Capabilities
- Standard and Custom Coating Options Available

Spherical Manufacturing Capabilities			
	Commercial	Precision	High Precision
Diameter:	4 - 200mm	4 - 200mm	4 - 200mm
Diameter Tolerance:	+0/-0.100mm	+0/-0.025mm	+0/-0.010mm
Thickness:	±0.100mm	±0.050mm	±0.010mm
Sag Height:	±0.050mm	±0.025mm	±0.010mm
Clear Aperture:	80%	90%	90%
Radius:	±0.3%	±0.1%	Fix to Test Plate
Power (P - V):	3.0λ	1.5λ	λ/2
Irregularity (P - V):	1.0λ	λ/4	λ/40
Centering (Beam Deviation):	3 arcmin	1 arcmin	0.5 arcmin
Bevel (Face Width @ 45°):	<1.0mm	<0.5mm	<0.25mm
Surface Quality:	80-50	40-20	10-5



SCAN HERE to compare the performance of different lens geometries.

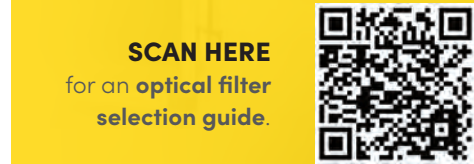
HARD-COATED OPTICAL FILTERS

- Wavelength Ranges from 193nm to 12.4μm
- 960 Standard Filter Coating Designs
- Custom Design, Manufacturing, and Testing Offered
- Laser-Line Designs Available for Ultrafast and Other Laser Systems



Hard-Coated Optical Filter Capabilities								
Types of Filters:	Filters for Fluorescence / Life Science Applications		Hard Coated Bandpass Filters			High-Precision Edge Filters		
	Fluorescence Bandpass Filters	Fluorescence Dichroic Filters	Narrow Bandpass Filters	Medium Bandpass Filters	Broad Bandpass Filters	Shortpass Filters	Longpass Filters	Dichroic Filters
Typical Specifications:	Transmission ≥95%		Transmission ≥95%			Transmission ≥95%		
	Blocking ≥OD6.0	Reflection ≥98%	Blocking ≥OD4.0			Blocking ≥OD4.0		Reflection ≥98%
	Bandwidths between 10 - 80nm	Transmitted Wavefront Distortion (TWD) ≤λ/4	Bandwidths between 5 and 20nm	Bandwidths between 25 and 50nm	Bandwidths ≥50nm	Slope Factor ≤1%		Transmitted Wavefront Distortion (TWD) ≤λ/4
	Environmental Durability per MIL-STD-810H Physical Durability per MIL-C-48497A		Environmental Durability per MIL-STD-810H Physical Durability per MIL-C-48497A			Environmental Durability per MIL-STD-810H Physical Durability per MIL-C-48497A		

\*Capabilities for notch filters, neutral density filters, and machine vision filters available online at [www.edmundoptics.com/filter-coatings](http://www.edmundoptics.com/filter-coatings)



SCAN HERE for an optical filter selection guide.

OPTICAL PRISMS



- Stock or Custom, from Design and Prototype to Volume Production
- Wide Assortment of Prism Shapes In Stock
- Build-to-Print Capabilities
- Available in Many Glass Types with a Variety of Standard and Custom Coatings

Optical Prism Manufacturing Capabilities			
	Commercial	Precision	High Precision
Dimensions:	2 - 200mm	2 - 150mm	2 - 75mm
Dimensional Tolerance:	+0/-0.2mm	+0/-0.1mm	+0/-0.01mm
V-Height:	±0.25mm	±0.1mm	±0.03mm
Irregularity:	1.0λ	λ/4	λ/20
Prism Physical Angle Tolerance:	±3 arcmin	±1 arcmin	45° & 90° ±0.5 arcsec
Penta Prism Deviation:	±5 arcmin	±3 arcmin	±0.5 arcsec
Max Bevel (Face Width @ 45°):	±0.5mm	±0.3mm	±0.05mm
Surface Quality (Scratch Dig):	80-50	40-20	10-5
Bonded Prism Assembly Beam Deviation:	5 arcmin	3 arcmin	0.5 arcmin
Pyramid Tolerance:	±5 arcmin	±3 arcmin	±0.5 arcmin



SCAN HERE to learn about different prism types and applications.

ABSORPTIVE OPTICAL FILTER GLASS

- >60 SCHOTT Optical Filter Glass Types in Stock
- Online Tool for Quick Quotes of Custom Filter Glass at [www.edmundoptics.com/tools/opticalfilterglass](http://www.edmundoptics.com/tools/opticalfilterglass)
- Build-to-Print Manufacturing and Full-Custom Design
- Rapid Turnaround for Prototypes



Optical Filter Glass Manufacturing Capabilities		
	Commercial	High Precision
Dimensions:	5 - 50mm	3 - 160mm
Dimensional Tolerances:	±0.2mm	±0.05mm
Thickness:	1, 2, or 3mm	0.5 - 4.0mm
Thickness Tolerances:	±0.1mm	±0.05mm
Surface Finish*:	P2	P2 - P3
Surface Quality (Scratch-Dig):	80-50	20-10
Flatness:	2-3λ	λ/4
Neutral Density:	0.15 - 5.0 OD	
Geometry:	Round, Elliptical, and Rectangular	
Filter Glass Type:	Longpass, Shortpass, Bandpass, Neutral Density, and Combinations of Multiple Glasses	

\* Specifications per DIN ISO 10110. Manufacturing specifications per MIL-PRF-13830B also available.



SCAN HERE to learn more about all types of filters.

BEAMSPLITTERS



- Wide Variety of Beamsplitter Types Including Polarizing, Non-Polarizing, and Laser Line
- Customized Solutions for Prototype to Volume Production
- Design & Application Expertise for Complex Coating and Geometry Needs

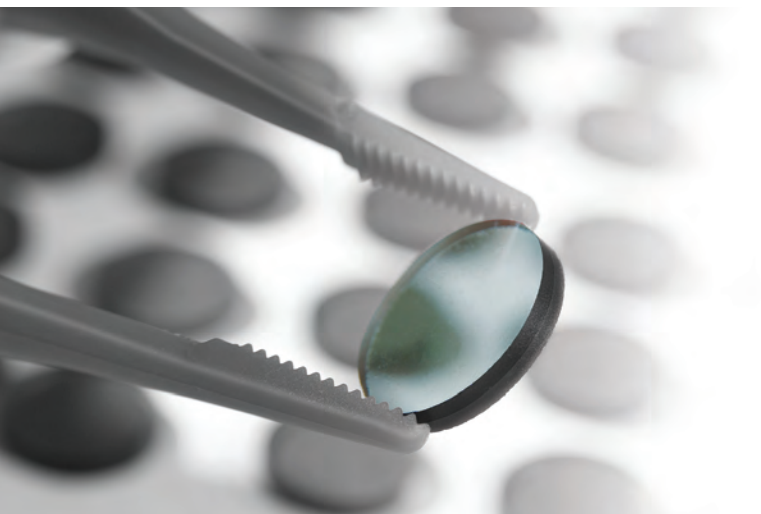
Beamsplitter Manufacturing Capabilities			
	Commercial	Precision	High Precision
Dimensional Tolerance:	±0.15mm	±0.08	±0.04
Dimensions:	5 - 75mm	5 - 75mm	5 - 75mm
Irregularity (or Flatness):	1.0λ	λ/8	λ/20
Surface Quality (Scratch Dig):	80-50	40-20	10-5
Max Bevel (Face Width @ 45°):	±0.5mm	±0.3mm	±0.05mm
Beam Deviation:	±5 arcmin	±3 arcmin	±0.5 arcmin
Ts - Tp  (Broadband Non-Polarizing):	<10%	<8%	<6%
Ts - Tp  (Laser Line Non-Polarizing):	<6%	<3%	<2%
R/T Splitting Ratios (Non-Polarizing):	30/70 to 90/10	30/70 to 90/10	30/70 to 90/10
R/T Splitting Ratio Tolerance:	±15%	±10%	±5%
Extinction Ratio (Polarizing):	100:1	500:1	> 1000:1
Wavelength Range:	400 - 1620nm	400 - 1620nm	350 - 1620nm

\* Some values may depend on material and the other required specifications



**SCAN HERE**  
to watch a recorded webinar about different types of beamsplitters and tips for maximizing your application's performance.

POLYMER POLARIZERS



- Wide Range of Polymer Polarizers for Visible Applications
- Custom Sizes and Shapes for Linear and Circular Polarizers, and Retarders
- Lamination on Glass or Plastic Substrates for Improved Stability
- Online Tool for Quick Quotes of Custom Polarizers and Retarders at [www.edmundoptics.com/tools/polarizers](http://www.edmundoptics.com/tools/polarizers)

Linear Polarizer Manufacturing Capabilities*				
Specifications:	Linear Polarizing Film	PMMA Laminated	Glass Laminated	Wire-Grid Polarizing Film
Dimensions:	3 x 3mm - 600 x 1000mm	3 x 3mm - 600 x 900mm	6 x 6mm - 250 x 250mm	3 x 3mm - 240 x 80mm
Diameter:	3 - 600mm	3 - 600mm	6 - 250mm	3 - 80mm
Dimensional Tolerance:	According to DIN ISO 2768-1m/c			
Thickness:	0.18 - 1.00mm	1.00 - 3.00mm	2.00 - 3.50mm	0.08mm
Transmission:	Up to 44%		85%	
Extinction Ratio:	Up to 1:30,000			1:4,250

\*For specifications for circular polarizers and retarders, visit [www.edmundoptics.com/capabilities/polarizers](http://www.edmundoptics.com/capabilities/polarizers)

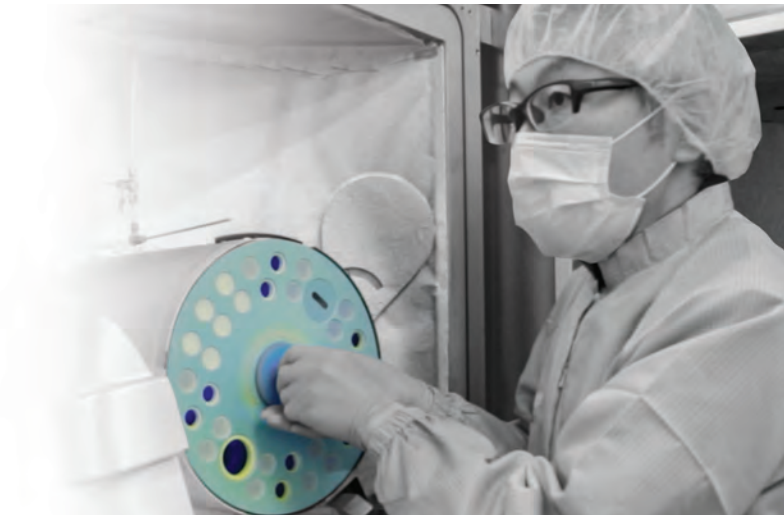


**SCAN HERE**  
to learn about polarization and how to manipulate it for different applications.

MIRRORS

- Wide Variety of Metallic and Dielectric Coatings
- High Laser Damage Threshold (LDT) and Ultra-High Reflectivity Options
- Standard or Custom, from Design and Prototype to Volume Production
- Superpolishing Capabilities for Surface Roughness Down to 0.5Å

Mirror Manufacturing Capabilities			
	Commercial	Precision	High Precision
Dimensions:	2.5 - 406.4mm		
Dimensional Tolerance:	±0.25mm	±0.1mm	±0.05
Flatness:	4-6λ	λ/10	λ/20
Surface Quality (Scratch Dig):	80-50	40-20	10-5
Coating Options:	Metallic, Broadband Dielectric, and Dielectric Laser V-Coats		
Reflectivity (Non-Laser):	85-99.98%		
Wavelength Range Covered:	13.5nm - >40μm		
Group Delay Dispersion (GDD) Range:	-4000 - 5000 fs <sup>2</sup>		
Substrate Options:	Metals, Glass, and Ceramics		
Geometries:	Flat, Elliptical, Spherical, and Parabolic		



**SCAN HERE**  
to learn about metallic mirror coatings.



DIAMOND TURNING

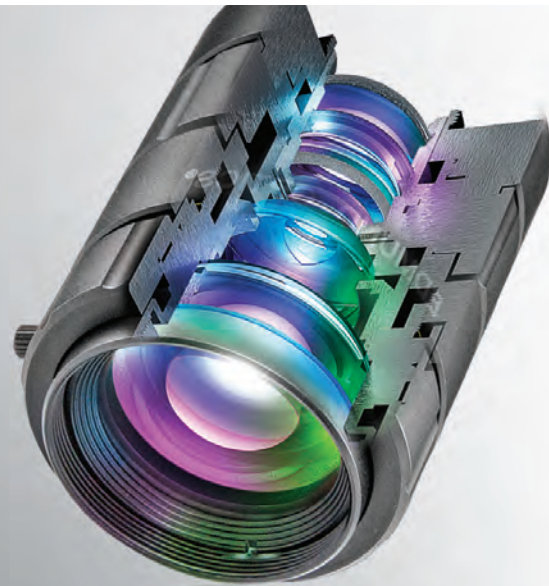
- Metals, Crystalline Materials, and Plastics
- Off-Axis Parabolic, Elliptical, and Toroidal Mirrors, Aspheric and Spherical Lenses, and Flatwork
- Build-to-Print Manufacturing and Full-Custom Design
- Wide Range of Coating Options

Diamond Turning Capabilities			
	Commercial	Precision	High Precision
Reflected Wavefront Error (P - V @ 632nm):	λ	λ/2	λ/8
Surface Quality:	80-50	60-40	40-20
Surface Roughness (RMS) Metals*:	150Å	100Å	<30Å
Surface Roughness (RMS): Crystalline Materials and Plastics	<50Å for Diameters 6.25 - 200mm		
Geometries:	Off-Axis Parabolas, Off-Axis Ellipses, Off-Axis Toroids, Spherical Surfaces, Aspheric Surfaces, and Planar Surfaces		
Angles:	0 - 90°		
Diameter (Off-Axis):	2 - 254mm		
Diameter (On-Axis):	8 - 254mm		
Coatings:	Uncoated, Aluminum, UV Enhanced Aluminum, Protected Gold, Bare Gold, Protected Silver, Anti-Reflection, and Custom (upon request)		
Materials:	Metals (Aluminum, Copper, Brass, and Nickel-Plated Surfaces), Crystalline Materials (Germanium, Silicon, Calcium Fluoride, and Zinc Selenide), and Plastic (Acrylic and Zeonex)		



**SCAN HERE**  
to watch a video about diamond turning at Edmund Optics®.





- Full Custom Lens Design for Your Specific Needs
- Designs for Newest Technology Trends Including Stability Ruggedized Lenses, Integrated Liquid Lenses, and Ultra-High Resolutions (100+ MP)
- M12, C-Mount, Factory Automation, Telecentric Lenses, & More
- Global In-Region Engineering Support & Service
- Volume Manufacturing & Designs Optimized for Integration

The expert team of Edmund Optics® optical and optomechanical designers, project managers, and manufacturing engineers seamlessly support our customers from the ground-up and at each step of the project journey. From product design and prototyping, to scale-up and volume production, we are proud to deliver award-winning and innovative imaging lenses designed for the most demanding and cutting-edge applications.

Imaging Lens Assembly Capabilities			
	Fixed Focal Length Lenses	Telecentric Measuring Lenses	Fixed Magnification Lenses
Sensor Sizes:	Up to 43.3mm	Up to 43.3mm	Up to 90mm
Resolution:	Up to 120 MegaPixels	Up to 32 MegaPixels	Up to 16k Line Scan
Field of View:	>105°	Up to 242mm	0.2mm - 186mm
Lens Mounts:	C-Mount, TFL-Mount, TFL-II Mount, F-Mount, S-Mount, M42	C-Mount, F-Mount, M42	C-Mount, F-Mount, M42, M72



**SCAN HERE**  
to watch a video about  
**how an EO imaging lens is made.**

### RUGGEDIZED IMAGING LENSES FOR HARSH ENVIRONMENTS

- Stability Ruggedized Lenses with Streamlined Mechanics and Lens Elements Glued in Place to Protect from Shock and Vibration
- Ingress Protected Lenses Sealed from Moisture that Meet IEC Ratings of IPX7 and IPX9K
- Athermal Lenses that Maintain Performance Over Wide Temperature Ranges
- Industrial Ruggedized Lenses with Streamlined Mechanics for OEM Integration

### METROLOGY

- MTF & Resolution Testing
- Zygo® VeriFire™, QED ASI, & Other Interferometers
- Coordinate Measurement Machines (CMM)
- Zygo® NewView™ Optical Profiler
- OptiPro UltraSurf 4X 100 Metrology Systems
- Bespoke Testbeds
- T-Number
- Telecentricity & Distortion
- Relative Illumination

**EDMUND OPTICS®**  
**Innovation**  
Summits

**SCAN HERE**  
Learn all about **building better imaging systems** in our Edmund Optics® Innovation Summit virtual event series.



For more information on **IMAGING ASSEMBLIES**, visit [www.edmundoptics.com/capabilities/imaging-lens-assemblies](http://www.edmundoptics.com/capabilities/imaging-lens-assemblies)

- Internal Volume Coating Capabilities from 248nm to >40µm
- Custom Coating Design from UV to LWIR Spectral Ranges
- Well-Established Partners Covering Selective UV Ranges From 4.1nm to 157nm
- Anti-Reflective, Highly-Reflective, Filter, Polarizing, Beamsplitter, and Metallic Designs
- High Laser Damage Threshold (LDT) and Ultrafast Laser Coatings

Optical coatings are a critical portion of the finished optical component or assembly. Accurate optical coating design and production can mean the difference between the component failing in the field or lasting for the intended lifetime of the project. Edmund Optics® has extensive coating capabilities, and expertise in producing coatings for life science applications and medical devices, harsh environment imaging assemblies, and applications throughout the ultraviolet (UV), visible (VIS), and infrared (IR) spectral regions. All optics are meticulously cleaned, coated, and inspected in a clean room environment, and subjected to the environmental, thermal, and durability requirements specified by our customers.

### ION BEAM SPUTTERED (IBS) COATINGS

- Highly-Repeatable Coatings Offering Sharp Spectral Transitions
- Less Affected by Environmental Factors, Including Temperature and Humidity
- Ideal for Hard-Coated Optical Filters and High-Precision Laser Optics



### MANUFACTURING EQUIPMENT

- E-Beam Deposition
- Ion-Assisted Deposition
- Advanced Plasma Source (APS)
- Ion Beam Sputtering (IBS)
- Thermal Evaporation
- High-Precision Optical Monitoring
- Hard Coatings for Stringent Environments and Durability
- Automated Ultrasonic Cleaning

For more information on **OPTICAL COATINGS**, visit [www.edmundoptics.com/coatings](http://www.edmundoptics.com/coatings)



**SCAN HERE**  
to learn about **coating theory**  
and **different coating techniques.**



Optical Coating Capabilities	
Dimensions (Diameter or Square):	2 - 1000mm
Reflectivity:	0.1 - 99.98%
Anti-Reflective Wavelength Range:	248 - 12,000nm
Highly-Reflective Wavelength Range:	13.5 - >40,000nm
Group Delay Dispersion (GDD) Range:	-4000 - 1600fs²
Longpass Filter Cut-On Wavelength:	240 - 7300nm
Bandpass Filter CWL, OD, and Bandwidth:	193 - 10,600nm, >OD 7, 1nm - Broadband
Notch Filter CWL:	355 - 1064nm
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
Laser-Induced Damage Threshold (LIDT):	>40 J/cm² @ 1064nm @ 20ns @ 20Hz Pulses, Measured
Durability:	MIL-PRF-13830B APP C, PARA C.3.8.4, PARA C.3.8.5, MIL-C-48497A

### METROLOGY

- Spectrophotometers - Agilent Cary, Hitachi, PerkinElmer LAMBDA, PerkinElmer FTIR, Varian, Essent Optics, and Photo RT
- In-House Laser Damage Threshold Testing (LDT)
- UltraFast Innovations White Light Interferometers for Group Delay Dispersion Testing
- Olympus MX51 DIC Microscopes
- Filmetrics F20 Thin Film Analyzer
- ZYGO NewView 9000 for Surface Roughness Metrology
- Cavity Ring-Down Spectroscopy for High Reflectivities
- Environmental Test Chambers: Temperature, Humidity, Salt Spray
- Automated Abrasion Tester for Durability
- Atomic Force Microscopy (AFM)
- Photothermal Common-Path Interferometry



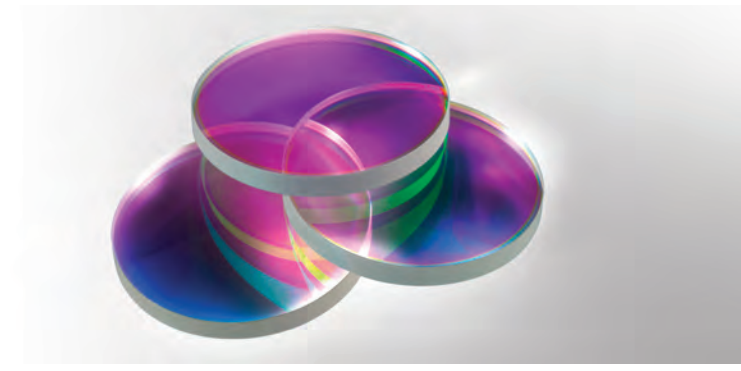
- In-House Manufacturing of Laser Optics Components and Assemblies
- State-of-the-Art Metrology Utilized to Consistently Meet Specifications
- Standard Off-the-Shelf Components Ready to Ship Today
- Fully Custom Design and Manufacturing for Prototyping through Volume Production

Edmund Optics® high-precision laser optics manufacturing is supported by a host of in-house metrology including a laser damage threshold (LDT) testing lab. Whether you need high LDT coatings, tightly-toleranced laser optics substrates, optical components, or laser assemblies, we have the expertise and state-of-the-art equipment to make and measure the laser optics required for your application.

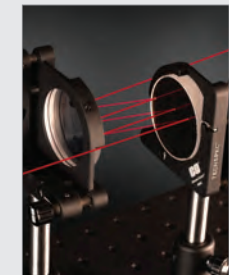


**SCAN HERE**  
to watch a video about **metrology**  
for laser optics manufacturing.

- Laser Mirrors, Windows, Lenses, Filters, Crystals, Beamsplitters, and Prisms
- Complex E-Beam Coatings: High LDT, Multi-Band Anti-Reflective or Highly-Reflective
- Ion Beam Sputtered (IBS) Coatings for Low Loss
- UV, Visible, NIR, SWIR, MWIR, and LWIR Spectral Ranges
- Designs for Common Laser Sources as Well as Uncommon Tunable Lasers
- Ultrafast Coatings for Group Delay Dispersion Values from -4000 – 5000 fs<sup>2</sup>



**ULTRAFAST LASER OPTICS**



- Highly-Dispersive Mirrors, Low Group Delay Dispersion (GDD) Optics, and Beam Expanders
- White Light Interferometry and Cavity Ring Down Spectroscopy for Guaranteed GDD and Reflectivity
- Internal Manufacturing and Strategic Partners Including UltraFast Innovations GmbH

**SUPERPOLISHING**



- Minimize Scatter with Ultra-Low RMS Surface Roughness <1Å
- Parts-per-Million Level Scattering
- Supported by State-of-the-Art Metrology Including Atomic Force Microscopy and White Light Interferometry

**METROLOGY: IF YOU CAN'T MEASURE IT, YOU CAN'T MAKE IT**



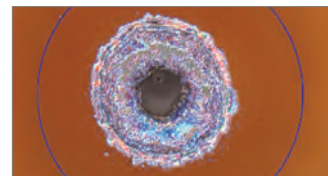
**Spectrophotometry**

Used to characterize reflective and transmissive spectral performance. Large spectral measurement range of 120nm - 20µm.



**Interferometry**

Highest accuracy transmitted and reflected wavefront measurements down to <math>\lambda/20</math>



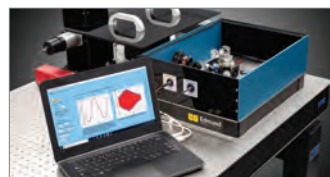
**LDT Testing**

Testing both in-house and outsourced for guaranteed laser damage threshold (LDT) or laser-induced damage threshold (LIDT)



**Cavity Ring-Down Spectroscopy**

Loss measurement sensitive enough for reflectivities of 99.9xxx% at 1064, 532, and 355nm



**White Light Interferometry**

Accurately measure group delay dispersion (GDD) of multilayer ultrafast optics from 250nm to 2400nm



**Shack-Hartmann Wavefront Sensors**

Transmitted and reflected wavefront measurements down to  $\lambda/10$  from 266nm to 1100nm



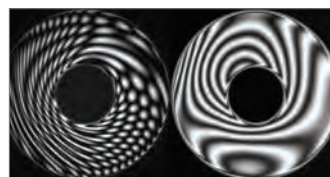
**Differential Interference Contrast (DIC) Microscopy**

High sensitivity defect detection in transmissive materials up to magnifications of 100X



**Atomic Force Microscopy (AFM)**

High accuracy characterizations of surface roughness and feature sizes and locations



**Short Coherence Length Interferometry**

Special LED source used to measure parallel, flat surfaces while minimizing reflections from back surfaces



**Photothermal Common-Path Interferometry**

Accurately measure absorption for better characterization of the spectral properties of optical coatings and substrates



**Coordinate Measuring Machines (CMMs)**

Measure mechanical dimensions of optical components



**Non-Contact 3D Profilometry**

Verify surface profile of precision aspheric lenses

**LASER OPTICS ASSEMBLIES**

- Beam Expanders, Focusing Objectives, and Other Laser Optics Assemblies
- Laser Line and Broadband Coatings from 257nm to 3µm
- Low Group Delay Dispersion (GDD) Designs for Ultrafast Systems, Including Reflective Designs
- High-Power Assemblies with No Issues from Internally-Focusing Ghost Images
- Build-to-Print Capabilities

**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
Focusing Mechanisms Available:	Sliding Optics, Rotating Optics, Fixed Focus
Ruggedization Available:	Athermalization, Shock and Vibration, Sealing from Contaminants
Testing/Design Specifications:	Transmitted Wavefront Error, Power in the Bucket / Energy on Target, Focused Spot Size
Assembly Size:	From Handheld, to Vehicle-Mounted, to Large Stationary Systems

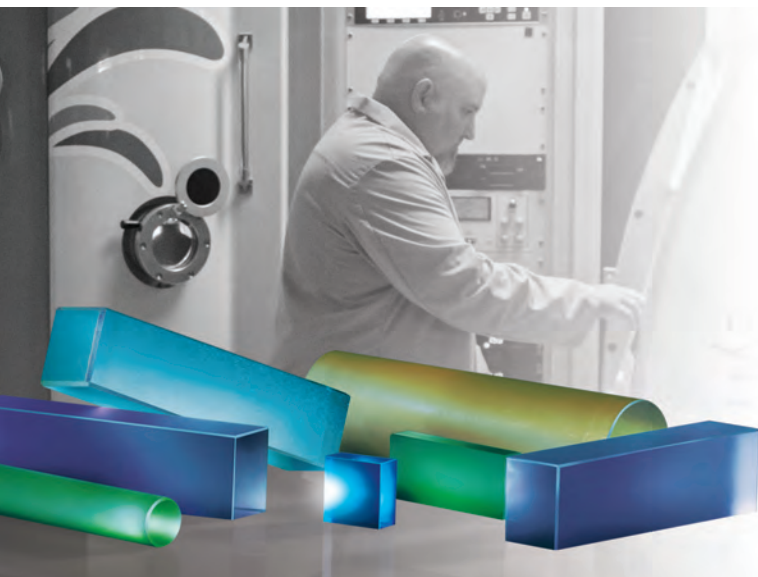


**SCAN HERE**  
to learn about  
laser beam expanders.



For more information on **LASER OPTICS**, visit [www.edmundoptics.com/LO](http://www.edmundoptics.com/LO)

For more information on **LASER OPTICS**, visit [www.edmundoptics.com/LO](http://www.edmundoptics.com/LO)



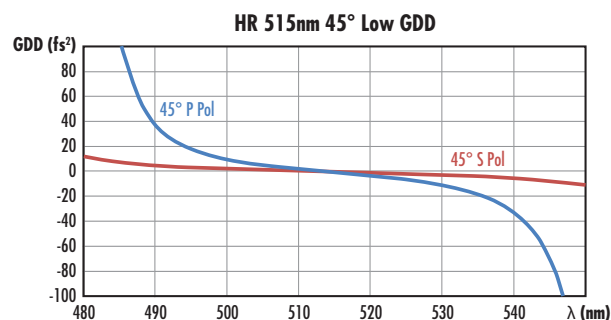
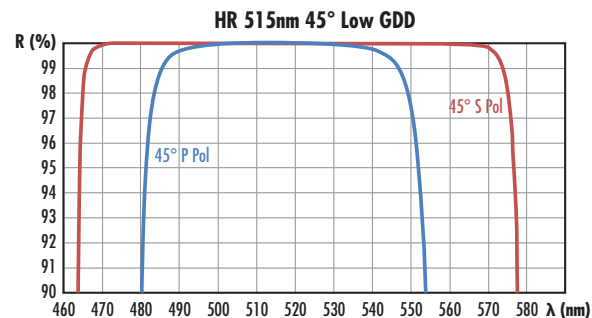
## EDMUND OPTICS® FLORIDA LASER OPTICS CENTER

- Dedicated Laser Optics Manufacturing Center of Excellence
- High Laser Damage Threshold (LDT) Coating Options Covering 248nm to 12µm
- Laser Crystal Cutting, Polishing, and Coating

Edmund Optics® has acquired Quality Thin Films (QTF), a leader in the industry offering a wide range of optical components with high laser damage threshold (LDT) and laser crystal coatings from the ultraviolet to the far infrared. This acquisition allows Edmund Optics to expand its laser optics manufacturing capabilities across crystal and glass fabrication, polishing, metrology, high laser damage threshold and diamond-like carbon coatings, inspection, and testing. The Florida Laser Optics Center's 34,000 sq. ft (3,159 m<sup>2</sup>) facility, located outside of Tampa, FL, is home to approximately 30 employees, many of whom are laser optics experts.

### COMPLEX OPTICAL COATINGS

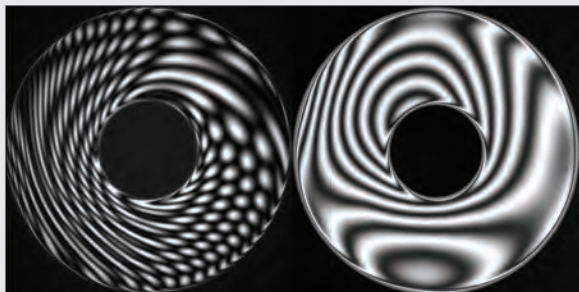
- Design and Deposition of Optical Coatings for Both Catalog and Custom Laser Optics
- Complex Coatings Including Multi-Band Anti-Reflective or Highly-Reflective E-beam Coatings
- High LDTs and Control of Group Delay Dispersion (GDD) for Ultrafast Applications



**SCAN HERE**  
to watch how laser crystals are polished and coated in the Florida Laser Optics Center.

### FEATURED METROLOGY: SHORT COHERENCE LENGTH INTERFEROMETRY

Short coherence length interferometers using specialized LEDs as their light source are able to measure parallel, flat surfaces without noise from light reflecting off of the back surface (*right*), while conventional laser-based interferometers will be affected by this noise (*left*). This is particularly useful for thin substrates with stress compensating coatings on the backside. Image from InterOptics LLC.



For more information on **THIS FACILITY**, visit [www.edmundoptics.com/QTF](http://www.edmundoptics.com/QTF)

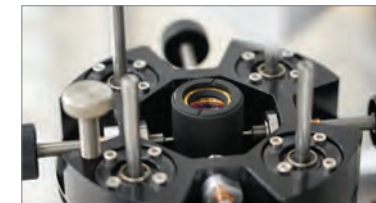
## EDMUND OPTICS® TUCSON ASSEMBLY AND ADVANCED DESIGN FACILITY

- Advanced Design and High-Volume Manufacturing Services
- Commercial and ITAR-Compliant Facility
- Cleanroom Assembly and Advanced Testing for MTF, Stray Light, Thermal Cycling, Shock and Vibration, and More
- Advanced Assemblies Requiring Active Alignment, Electronics Integration, and/or Environmental Ruggedization

Edmund Optics® now operates a second facility in Tucson, Arizona. This location offers Assembly and Advanced Design services. The 22,284 sq. ft (2,070 m<sup>2</sup>) facility includes ISO Class 6 cleanrooms for assembly, ISO Class 7 cleanrooms for incoming inspection, and numerous testing capabilities such as modulation transfer function (MTF), straylight, laser beam profiling, thermal cycle, shock, and vibration. Our skilled team of optical assembly technicians has extensive experience with high-performance systems in cleanroom facilities. Customers now have access to more sophisticated commercial and ITAR compliant offerings at a new location on the US West Coast. With this new facility, Edmund Optics strengthens a globally diversified supply chain that lowers risk for customers.

### PRECISION OPTICAL ASSEMBLIES AND SYSTEMS

- Imaging Lens Assemblies
- Beam Delivery Systems
- Telescopes
- Microscopes



### AREAS OF EXPERTISE

- Transfer from Concept to Volume Manufacturing
- Rapid Prototyping
- Cleanroom Assembly
- Testing and Certification

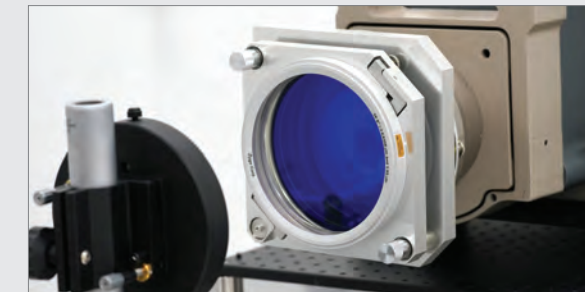


**SCAN HERE**  
to learn about Edmund Optics' design services.



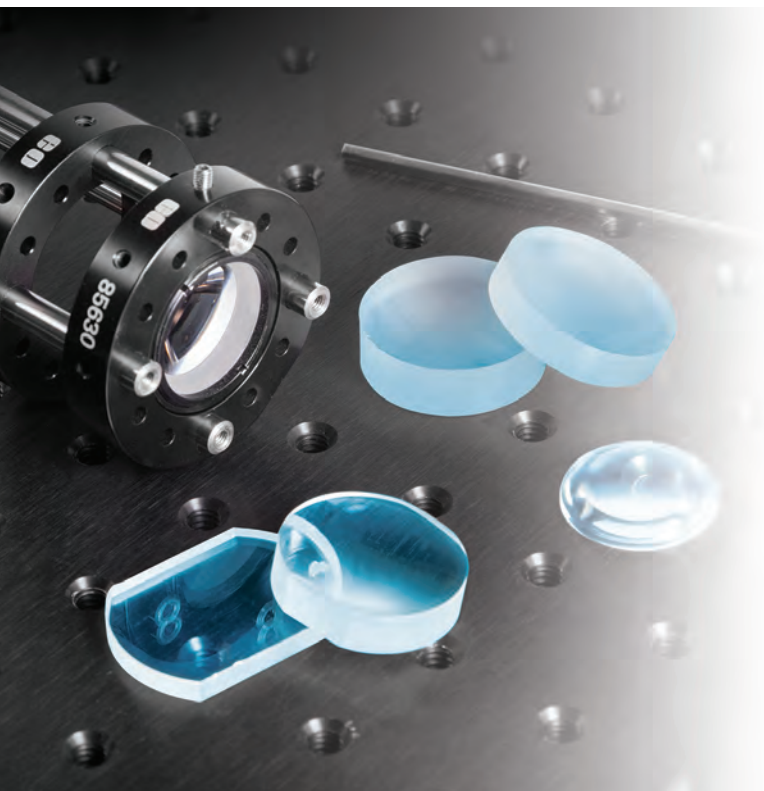
### SPECIALIZED TESTING INCLUDES:

- Modulation Transfer Function (MTF)
- Wavefront
- Environmental Ruggedization
- Stray Light
- Laser Beam Profiling
- High-Precision Mechanical Tolerances
- Development of Application-Specific Tests



For more information on **THIS FACILITY**, visit [www.edmundoptics.com/tucson-assembly](http://www.edmundoptics.com/tucson-assembly)





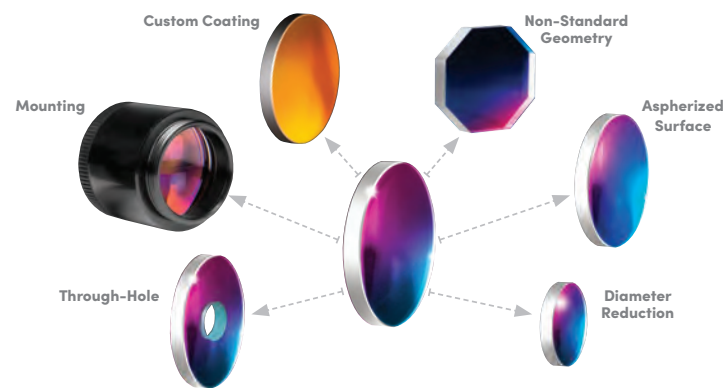
▶ CUSTOMIZED OPTICS IN 2-3 WEEKS

When developing a product, being able to quickly and easily iterate your prototypes is critical.

In addition to our immediately available inventory of over 34,000 standard optics, quick “modified standard” customizations are available in just **2-3 weeks**, simplifying the path to production.

Our modification services include: customizing the size, shape, and edges of standard optics; improving the surface figure or accuracy of the optical surface; sorting; mounting; kitting; inspection; and more! Find an achromat that has everything you need, but it’s just a little too big? We can edge it down for you. What about that mirror that you need in a non-standard size? We can cut it for you. Looking for a customized inspection report? We can measure it for you.

One Standard Optic = Infinite Possibilities

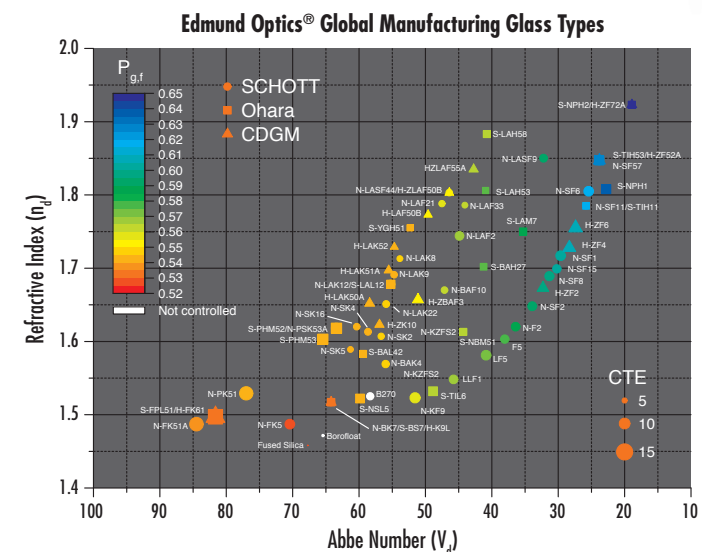


SCAN HERE to learn more about our modified standard program.

FULL CUSTOM FAST!

If off-the-shelf or modified standard components do not meet your prototyping needs, you can utilize our fully-custom prototyping capabilities to obtain custom glass components in a matter of days to a maximum of a few weeks.

Edmund Optics® maintains an inventory of over 70 of the most common optical glass types at all manufacturing sites. Using these materials reduces lead time of raw materials and facilitates quick prototyping.

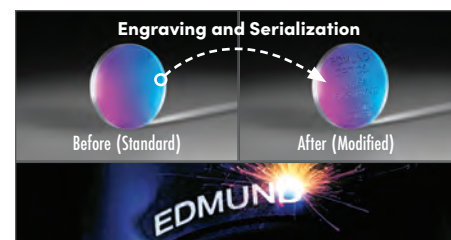
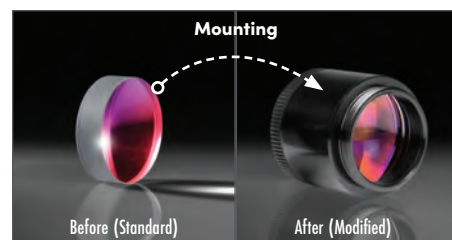
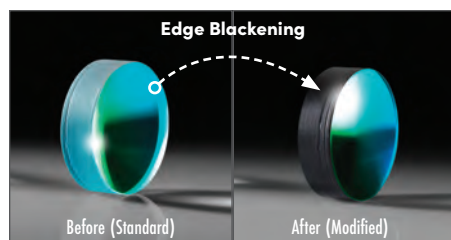
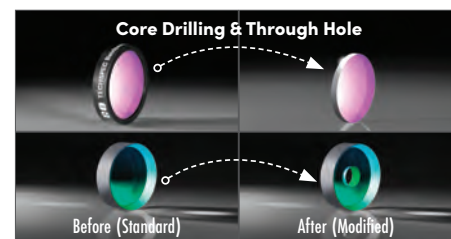
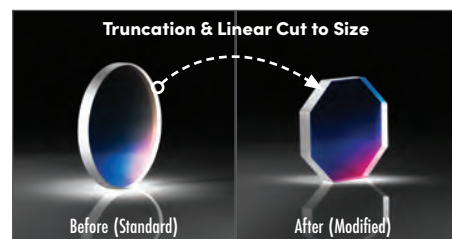
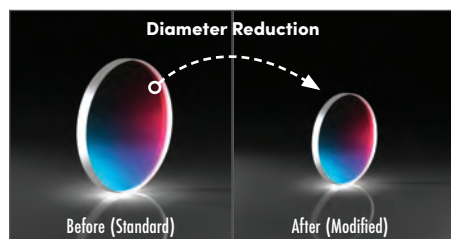


Glass map indicating the Refractive Index ( $n_d$ ), Abbe Number ( $V_d$ ), Coefficient of Thermal Expansion (CTE), and Relative Partial Dispersion ( $P_g$ ).



SCAN HERE to download Edmund Optics' global manufacturing glass types chart.

MODIFICATION SERVICES OFFERED

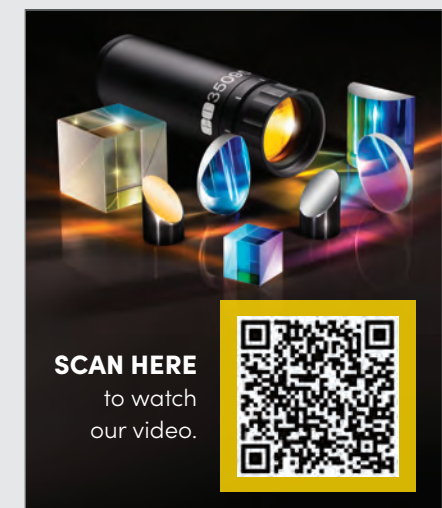


WHAT CAN WE MAKE FOR YOU? Learn more at [www.edmundoptics.com/modify](http://www.edmundoptics.com/modify)

13 CREATIVE "HACKS" FOR RAPID PROTOTYPING

While every application has its own timelines, credentials, and specifications, there are several techniques that may be commonly utilized to decrease the amount of time required for prototyping. Below are several of the 13 creative “hacks” that can be used to quickly and efficiently make prototypes of optical sub-systems:

- #1 – Go monochromatic to reduce element count and complexity
- #2 – Approximate custom "best-form" elements with available standard singlets
- #3 – Flip imaging lenses to use them as objectives
- #4 – Customize compound assemblies with standard optics
- #5 – Utilize inner diameter threaded prototyping tubes



SCAN HERE to watch our video.



For **FULL GLASS** and **ZEMAX GLASS CATALOGS**, visit [www.edmundoptics.com/preferred-glass](http://www.edmundoptics.com/preferred-glass)



Edmund Optics® manufactures and supplies customers around the globe with millions of precision optical components and optical assemblies. Whether standard, modified standard, or custom, we have the expertise and resources necessary to manufacture optical products based on your project's specific requirements. Our dedicated and skilled team members ensure that you receive the optimal solution for your application, while our quality assurance teams guarantee the best final products.

### Additional Requirements? We've Got You Covered!

- Highly Flexible Volume Order Servicing
- Support Blanket Orders and Other Stocking Agreements
- Competitive Volume Discounts
- Well Versed in Configuration Control, Change Control, and Copy Exact Requirements
- Seamless Federal Acquisition Regulation (FAR), Defense Federal Acquisition Regulation (DFAR), Quality Assurance Provision (QAP), and Testing Requirement Flow-Downs
- ITAR Registered and Compliant; Defense Priorities and Allocations System (DPAS) Servicing and Support
- Global Supply Chain Network with Global Warehousing – Quickly and Easily Supporting Your Projects Wherever You Prefer
- Comprehensive First Article Inspection Reports (FAIR) for Product Qualification

### DID YOU KNOW?

Edmund Optics® manufactures **over 2 million optical components** and **170,000 optical assemblies every year** at our global facilities.

## DEDICATED SUPPORT TEAMS FOR YOUR NEEDS

All customers with volume orders receive a dedicated support team to ensure their products are manufactured and specified to meet their needs, deadlines are kept, and a specified point of contact for general or technical questions is assigned. The support team consists of a project manager, solutions engineer, OEM sales representative, and regional sales manager.

### SAMPLE DEDICATED SUPPORT TEAM



**Project Manager**

The Project Manager coordinates all internal activities to meet project cost, schedule, and performance requirements for optical assemblies.



**Solutions Engineer**

Your technical resource for your custom optics requirements provides suggestions on cost-effective and manufacturable optics specifications.



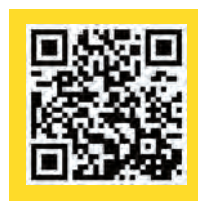
**OEM Sales Rep**

Your dedicated sales representative assists with volume price quotes, order placement, and delivery status to meet your project deadlines.



**Regional Sales Manager**

Your dedicated account manager provides on-site support and capability knowledge to develop and grow our relationship with you.



**SCAN HERE**  
to meet the team!

For more information on **VOLUME and OEM SERVICES**, visit [www.edmundoptics.com/volume](http://www.edmundoptics.com/volume)

## ▶ 6 WEEK VOLUME PRODUCTION TIME

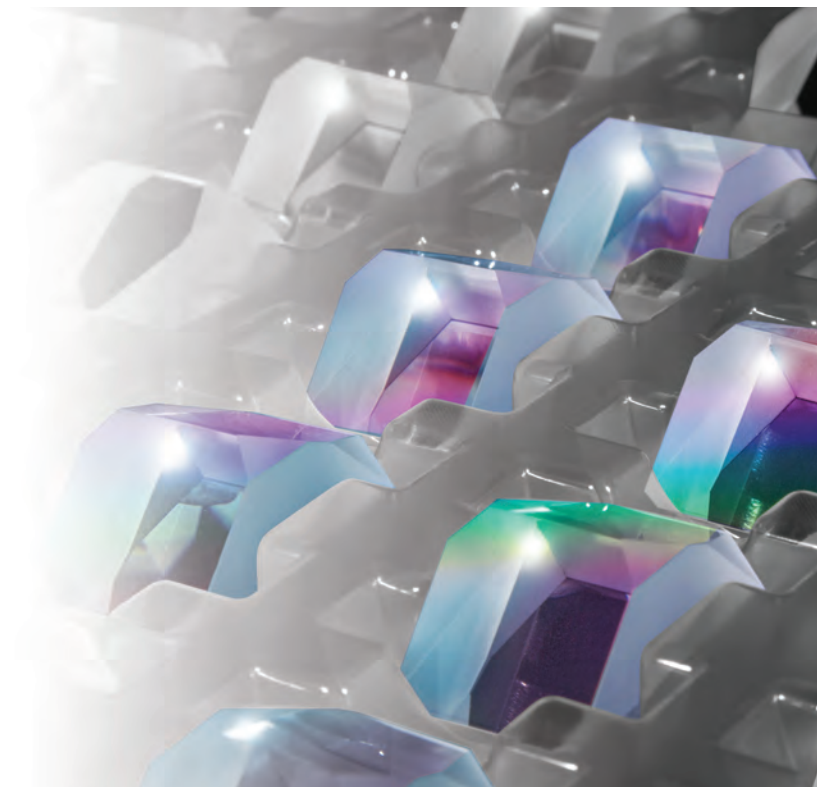
Edmund Optics® is proud to offer industry-leading **6 week production times** for **volume orders** of **custom optical components** at no premium!\*

In addition to our quality and customer service, we pride ourselves on speed and accuracy. We understand that ever-shrinking development and product cycles make short lead times crucial to many of our customers. For this reason, we offer quick turnaround solutions to get you the optics you need within your specified timelines. Our continued partnerships with glass and crystal suppliers allow us to get raw materials as quickly as possible, but exact lead times are dependent on global glass and crystal availability.

*\*Dependent on quantity, specifications, and glass availability. Exact lead time to be acknowledged at the time of order.*

## ENGAGE WITH US EARLY AND OFTEN

Speaking with our experts during your proof-of-concept phase can help significantly expedite custom manufacturing. We can help provide feedback on specifications to choose for your components and review your design for manufacturability, while assisting with possible cost reduction measures once your project moves from prototype to production.



**SCAN HERE**  
to contact us now!



## BEHIND THE SCENES IN OPTICAL MANUFACTURING

Watch the following two videos to see the manufacturing processes of both **aspheric lenses**, **imaging lens assemblies** and **laser crystals** in Edmund Optics' global manufacturing facilities.

**How an Aspheric Lens is Made**



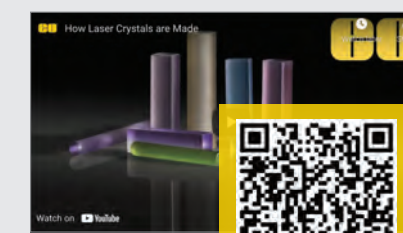
**SCAN HERE**

**How an EO Imaging Lens is Made**



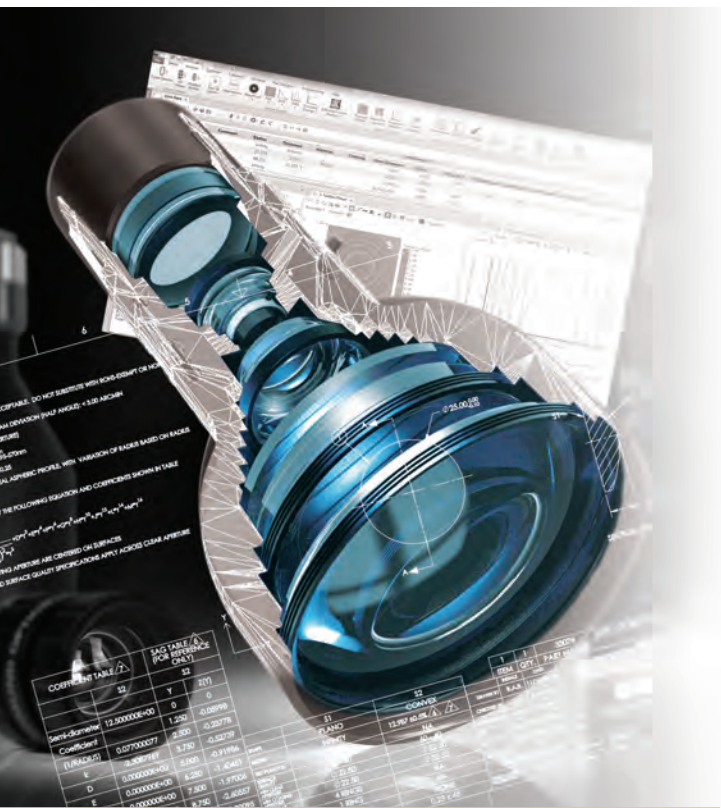
**SCAN HERE**

**How Laser Crystals are Made**



**SCAN HERE**

For a **FREE QUOTE**, contact us at [www.edmundoptics.com/contact-support](http://www.edmundoptics.com/contact-support)



- Over 30 Years of Experience Designing Optical Components and Optomechanical Assemblies
- Analysis Expertise Spans Zemax, Code V®, FRED™, Solidworks, Matlab®, Abaqus, and More
- Regional Engineering Support & Service Across the Globe
- Designs Optimized for Integration and High Production Yields

Edmund Optics® offers a variety of design services in order to meet the specialized needs of our customers. We excel at designing optical and optomechanical systems from components to assemblies and imaging to laser optics, spanning from the UV to IR. Our design engineers are well versed in tolerancing and complex optical and mechanical analysis.

Whether standard or custom, we have found that approaching the design and proof-of-concept stage with an eye towards manufacturability at the onset yields the fastest, most affordable, and most effective results. EO engineers are prepared to take your project from design to prototype to volume production.



For more **DESIGN ASSISTANCE**, visit [www.edmundoptics.com/design](http://www.edmundoptics.com/design)

**DID YOU KNOW?**

EO has over 230 engineers on staff, located at each of our global sales offices and manufacturing facilities, as well as our four dedicated design service locations in **Arizona, New Jersey, Germany, and China.**

**TIPS FOR DESIGNING MANUFACTURABLE LENSES AND ASSEMBLIES**

A successful lens design succeeds not only in the creation of a working model but also in manufacturing, assembly, testing, and implementation.

Visit this online resource to learn the nuances of designing manufacturable lens assemblies including:

- Geometry Considerations
- Tolerancing Methods and Assumptions
- Modeling Surface Irregularity
- Stack-ups of Assembled Systems



**SCAN HERE** for tips on **designing manufacturable lenses and assemblies.**



- Robust Global Compliance Systems
- Thorough Preventative and Corrective Action Procedures
- Commitment to Continuous Improvement
- ISO 9001:2015 Certified and ITAR Compliant

Edmund Optics® is committed to ensuring product and procedural quality. Guided by ISO 9001 certification standards, we employ a strict global quality program that is monitored by experienced staff and supported by the most innovative optical testing available. EO-manufactured products undergo rigorous and thorough testing as part of our quality program and in compliance with EO's global quality procedures, as well as a host of ISO and mil-spec standards.

Additionally, Edmund Optics® has documented plans for improving resource efficiency and waste reduction through the Environmental Management System (EMS) ISO 14001. We hope our initiative will develop and sustain both supply and demand for greener goods, services and products, and reduce waste both in and outside of the company.



**EDMUND OPTICS® IS COMPLIANT WITH:**

- ISO 9001:2015
- ISO 14001:2015
- ISO 13485:2016
- ANSI / ASME Y14.5
- ISO 10110
- MIL-C-48497A
- MIL-STD-810
- MIL-PRF-13830B
- MIL-C-675C



**STATE-OF-THE-ART METROLOGY**

**OPTICAL METROLOGY CAPABILITIES**

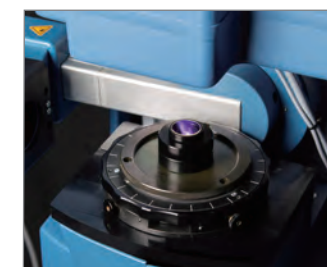
- Interferometers, Profilometers, Coordinate Measurement Machines (CMM), and a host of Optical and Mechanical Metrology
- Radiometrics: Stray Light, Veiling Glare, and More
- Semi-Automated MTF Measurement Equipment
- UV/VIS/NIR/IR Coating Characterization through Varian and PerkinElmer Spectrophotometers and Fourier Transform Infrared (FTIR) Spectroscopy
- Laser-Induced Damage Threshold (LIDT) and Beam Quality (M<sup>2</sup>) Measurement
- Environmental Testing Equipment such as Vibration, Humidity, Immersion, and Thermal Cycling
- Calibration of Equipment in Accordance with FDA 21 CFR Part 11, ISO 9001, ISO 13485, and AS9100 via GageTrak by Cybermetrics
- Over 50 Employees in Quality Control Functions Across the Company
- Product Testing and Certification Reports Available Upon Request

**IN-HOUSE OPTICAL ASSEMBLY TESTING**

- Modulation Transfer Function (MTF)
- Stray Light
- Telecentricity
- Wavefront Distortion
- White Light Interferometry
- Mechanical Profilometry
- Laser Beam Profiling
- Athermalization and Ruggedization
- Much More!



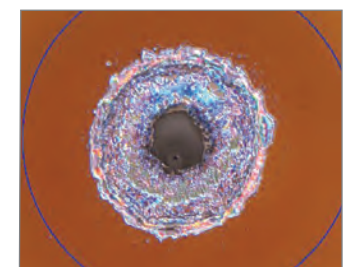
**QED ASI Aspheric Stitching Interferometer**



**Trioptics ImageMaster® MTF Test Station**



**Zygo® Interferometer**



**Laser-Induced Damage Threshold (LIDT) Testing**

To learn more about our **STATE-OF-THE-ART METROLOGY**, visit [www.edmundoptics.com/metrology](http://www.edmundoptics.com/metrology)

# TIPS FOR DESIGNING MANUFACTURABLE LENSES & ASSEMBLIES



A successful lens design succeeds not only in the creation of a working model but also in manufacturing, assembly, testing, and implementation. Occasionally, a lens may appear to succeed in conception but fail in one of the subsequent phases of manufacturing, assembly, or testing. Designers must consider the individual lens element geometry, the assembly setup, and the tolerancing models when creating an optic from scratch.

## GEOMETRY CONSIDERATIONS

- Oversize lenses to ensure that the edge thickness is not too small and not too sharp, such that the edge would be prone to damage.
- It is suggested to keep the edge thickness above ~0.7mm, at a diameter 1mm larger than the intended final diameter of the lens.
- The Karow or Z-factor, which measures the ability for a lens to center itself automatically between bell chucks, also known as bell clamps, is given by:

$$Z = \left[ \frac{D_1}{R_1} + \frac{D_2}{R_2} \right]$$

- $D_1, D_2$  are the bell chuck diameters (commonly equal to the lens clear aperture diameter).  $R_1, R_2$  are the radii of curvature for the first and second surfaces. Convex and concave surfaces respectively have positive and negative radii (Figure 1).

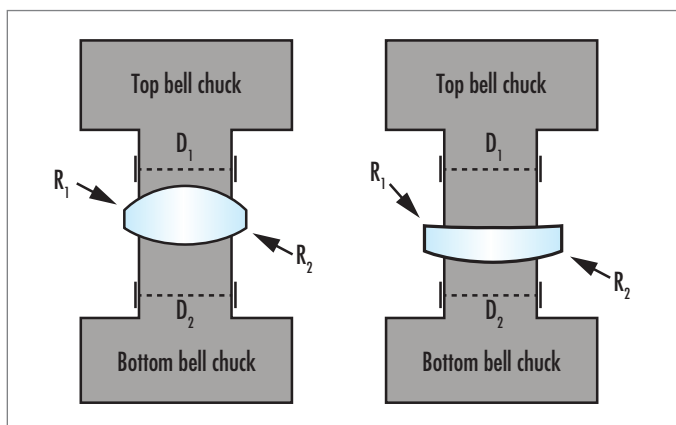


Figure 1: The left lens Karow factor ( $Z = 2.5$ ) is greater than the right lens ( $Z = 0.4$ ). As such, the left lens would be easier to center via automated bell-chucking while the right would be more difficult.

- Lenses with a Karow factor greater than 0.56 will automatically center well via automated bell-chucking.
- Those with a Karow factor less than 0.56 may not automatically center and will need to be centered manually. To ensure that a lens can be centered, concentricity ( $\Delta r$ ) should be greater than 2mm as a rule of thumb:

$$|\Delta r| = |R_1| - |R_2| - |CT|$$

## STACK-UPS OF ASSEMBLED SYSTEMS

- Stack-up models should attempt to accumulate tilt and decenter effects while keeping elements anchored to the optical axis.
- To model a system, ensure each Monte Carlo or simulation based on random sampling from the probability distributions of all tolerances iteration, is configured with the correct stack-up of element tilts according to the element arrangement in the assembly (Figure 2).

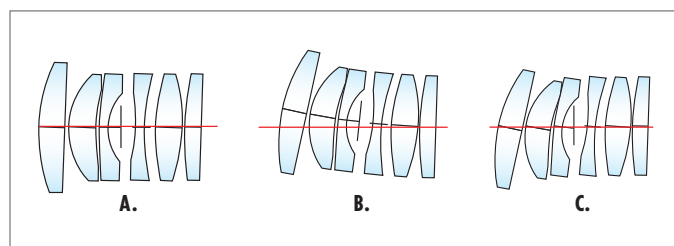


Figure 2: Three approaches to lens element tilt in a drop-together assembly. All elements are tilted by  $2^\circ$  in the same direction to illustrate the differences. A. Tilts are modeled independently. B. Tilts and decentration are accumulated in the order of assembly. C. Tilts are accumulated in the order of assembly, with no additional decentration; this motion is called shearing.

- Roll and decenter of an element can affect subsequent elements in the barrel.
- Connected elements will be “coupled” to a single rolling element and will move together.
- Only elements with convex rear surfaces contacting spacers have a coupled decenter.
- Elements with annuli or flat surfaces resting against a spacer can move independently (not coupled) from an initially decentered element (Figure 3).

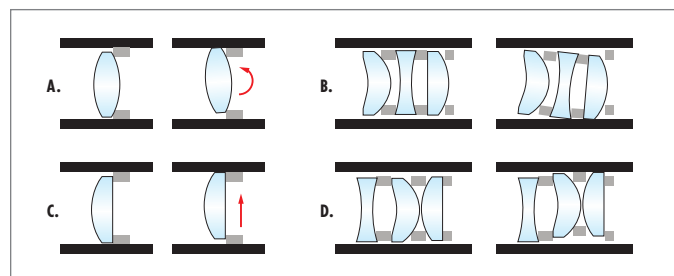


Figure 3: A. Roll motion of a lens element. B. Coupled roll motion. C. Decenter motion of a lens element. D. Coupled decenter motion.

- Oversimplifying tolerance models and designs can overlook possible manufacturing issues, and doing so increases the chances that designs will need revisions or additional iterations with increased levels of complexity.
- Increasing system model accuracy and using high-fidelity tolerancing methods early in design will require additional effort up front but will reduce expensive mistakes and save time in the end.

For more **OPTICS APPLICATION NOTES**, visit [www.edmundoptics.com/appnotes](http://www.edmundoptics.com/appnotes)

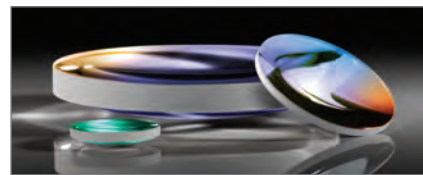
**ASPHERIC LENSES**



- 600+ Standard Aspheres Ready for Purchase
- Edmund Optics® is One of the Largest Aspheric Lens Manufacturers in the World

Aspheric Manufacturing Capabilities			
	Commercial	Precision	High Precision
Diameter:	10 - 200mm	10 - 200mm	10 - 200mm
Diameter Tolerance:	+0/-0.100mm	+0/-0.025mm	+0/-0.010mm
Asphere Figure Error (P - V):	3µm	1µm	<0.06µm
Sag:	25mm max	25mm max	25mm max
Typical Slope Error:	1µm per 1mm window	0.35µm per 1mm window	0.15µm per 1mm window
Centering (Beam Deviation):	3 arcmin	1 arcmin	0.5 arcmin
Center Thickness Tolerance:	±0.100mm	±0.050mm	±0.010mm
Surface Quality (Scratch Dig):	80-50	40-20	10-5
Aspheric Surface Metrology:	Profilometry (2D)	Profilometry (2D & 3D)	Interferometry

**SPHERICAL LENSES**



- 6,300+ Standard Spherical Lenses Ready for Purchase
- Available in Glass and Crystalline Materials with a Variety of Standard and Custom Coatings

Spherical Manufacturing Capabilities			
	Commercial	Precision	High Precision
Diameter:	4 - 200mm	4 - 200mm	4 - 150mm
Diameter Tolerance:	+0/-0.100mm	+0/-0.025mm	+0/-0.010mm
Thickness:	±0.100mm	±0.050mm	±0.010mm
Sag Height:	±0.050mm	±0.025mm	±0.010mm
Clear Aperture:	80%	90%	90%
Radius:	±0.3%	±0.1%	Fix to Test Plate
Power (P - V):	3.0λ	1.5λ	λ/2
Irregularity (P - V):	1.0λ	λ/4	λ/40
Centering (Beam Deviation):	3 arcmin	1 arcmin	0.5 arcmin
Bevel (Face width @45 degrees):	<1.0mm	<0.5mm	<0.25mm
Surface Quality:	80-50	40-20	10-5

**PRISMS**



- Custom Prisms in a Wide Variety of Geometries
- Angle Tolerances Down to 0.5 arcsec and Irregularity Down to λ/20

Prism Manufacturing Capabilities			
	Commercial	Precision	High Precision
Dimensions:	2 - 200mm	2 - 150mm	2 - 75mm
Dimensional Tolerance:	+0/-0.2mm	+0/-0.1mm	+0/-0.01mm
V-Height:	±0.25mm	±0.1mm	±0.03mm
Irregularity:	1.0λ	λ/4	λ/20
Prism Physical Angle Tolerance:	±3 arcmin	±1 arcmin	45° & 90° ±0.5 arcsec
Penta Prism Deviation:	±5 arcmin	±3 arcmin	±0.5 arcsec
Max Bevel (Face Width @ 45°):	±0.5mm	±0.3mm	±0.05mm
Surface Quality (Scratch Dig):	80-50	40-20	10-5
Bonded Prism Assembly Beam Deviation:	5 arcmin	3 arcmin	0.5 arcmin
Pyramid Tolerance:	±5 arcmin	±3 arcmin	±0.5 arcmin

**BEAMSPLITTERS**



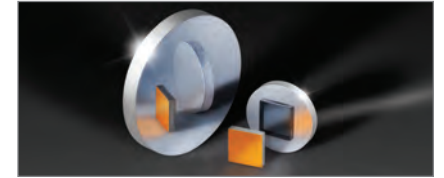
- Cube, Plate, Polarizing, Non-Polarizing, and Laser Line Capabilities
- Design and Application Expertise for Complex Coating and Geometry Needs

Beamsplitter Manufacturing Capabilities			
	Commercial	Precision	High Precision
Dimensional Tolerance:	±0.15mm	±0.08	±0.04
Dimensions:	5 - 75mm	5 - 75mm	5 - 75mm
Irregularity (or Flatness):	1.0λ	λ/8	λ/20
Surface Quality (Scratch Dig):	80-50	40-20	10-5
Max Bevel (Face Width @ 45°):	±0.5mm	±0.3mm	±0.05mm
Beam Deviation:	±5 arcmin	±3 arcmin	±0.5 arcmin
Ts - Tp  (Broadband Non-Polarizing):	<10%	<8%	<6%
Ts - Tp  (Laser Line Non-Polarizing):	<6%	<3%	<2%
R/T Splitting Ratios (Non-Polarizing):	30/70 to 90/10	30/70 to 90/10	30/70 to 90/10
R/T Splitting Ratio Tolerance:	±15%	±10%	±5%
Extinction Ratio (Polarizing):	100:1	500:1	>1000:1
Wavelength Range:	400 - 1620nm	400 - 1620nm	350 - 1620nm

**Mirror Manufacturing Capabilities**

	Commercial	Precision	High Precision
Dimensions:	2.5 - 406.4mm		
Dimensional Tolerance:	±0.25mm	±0.1mm	±0.05
Flatness:	4-6λ	λ/10	λ/20
Surface Quality (Scratch Dig):	80-50	40-20	10-5
Coating Options:	Metallic, Broadband Dielectric, and Dielectric Laser Line		
Reflectivity (Non-Laser):	85 - 99.98%		
Wavelength Range Covered:	13.5nm - >40µm		
Group Delay Dispersion (GDD) Range:	-4000 - 5000 fs²		
Substrate Options:	Metals, Glass, and Ceramics		
Geometries:	Flat, Elliptical, Spherical, and Parabolic		

**MIRRORS**



- 2,000+ Standard Mirrors Ready for Purchase
- High Laser Damage Threshold (LDT) and Ultra-High Reflectivity Options

**Optical Coating Capabilities**

Dimensions (Diameter or Square):	2 - 1000mm
Reflectivity:	0.1 - 99.98%
Anti-Reflective Wavelength Range:	248 - 12,000nm
Highly-Reflective Wavelength Range:	13.5 - >40,000nm
Group Delay Dispersion (GDD) Range:	-4000 - 5000 fs²
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, 1nm - Broadband
Notch Filter CWL:	355 - 1064nm
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
Laser Damage Threshold (LDT):	>40 J/cm² @ 1064nm @ 20ns @ 20Hz Pulses, Measured
Durability:	MIL-PRF-13830B APP C, PARA C.3.8.4, PARA C.3.8.5, MIL-C-48497A

**OPTICAL COATINGS**

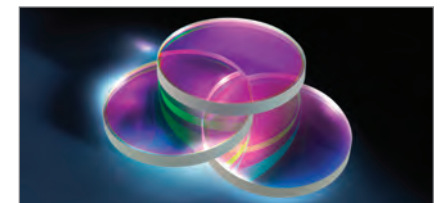


- In-House Custom Coating Design
- Anti-Reflective, Highly-Reflective, Filter, Polarizing, Beamsplitter, and Metallic Designs

**Laser Optics Components Capabilities**

Component Types	Coating Types	Ultrafast Laser Optics	Superpolishing
Laser Mirrors, Windows, Lenses, Filters, Crystals, Beamsplitters, and Prisms	Complex E-Beam Coatings: High LDT, Multi-Band Anti-Reflective or Highly-Reflective; Ion Beam Sputtered (IBS) Coatings for Low Loss	Highly-Dispersive Mirrors, Low Group Delay Dispersion (GDD) Optics, Reflective Focusing Optics, and Beam Expanders	Minimize Scatter with Ultra-Low RMS Surface Roughness <1Å for Parts-per-Million Level Scattering

**LASER OPTICS COMPONENTS**



- Designs for Common Laser Sources as Well as Uncommon Tunable Lasers

**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
Focusing Mechanisms Available:	Sliding Optics, Rotating Optics, Fixed Focus
Ruggedization Available:	Athermalization, Shock and Vibration, Sealing from Contaminants
Testing/Design Specifications:	Transmitted Wavefront Error, Power in the Bucket / Energy on Target, Focused Spot Size
Assembly Size:	From Handheld, to Vehicle-Mounted, to Large Stationary Systems

**LASER OPTICS ASSEMBLIES**



- Beam Expanders, Focusing Objectives, and Other Laser Optics Assemblies
- Laser Line and Broadband Coatings from 257nm - 3µm



# MANUFACTURING CAPABILITIES RESOURCE GUIDE

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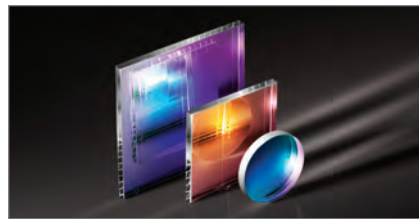
## IMAGING ASSEMBLIES



- Over 1.5 Million Imaging Lenses Sold
- Global In-Region Engineering Support & Service

Imaging Lens Assembly Capabilities			
	Fixed Focal Length Lenses	Telecentric Measuring Lenses	Fixed Magnification Lenses
<b>Sensor Sizes:</b>	Up to 43.3mm	Up to 43.3mm	Up to 90mm
<b>Resolution:</b>	Up to 120 MegaPixels	Up to 32 MegaPixels	Up to 16k Line Scan
<b>Field of View:</b>	>105°	Up to 242mm	0.2mm - 186mm
<b>Lens Mounts:</b>	C-Mount, TFL-Mount, F-Mount, S-Mount, M42	C-Mount, F-Mount, M42	C-Mount, F-Mount, M42, M72

## OPTICAL FILTER GLASS

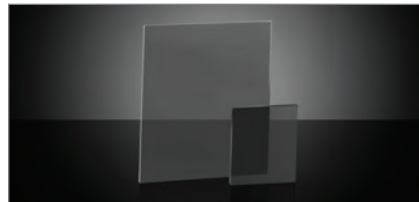


- >60 SCHOTT Optical Filter Glass Types in Stock
- No Minimum Order Quantity

Optical Filter Glass Manufacturing Capabilities		
	Commercial	High Precision
<b>Dimensions:</b>	5 - 50mm	3 - 160mm
<b>Dimensional Tolerances:</b>	±0.2mm	±0.05mm
<b>Thickness:</b>	1, 2, or 3mm	0.5 - 4.0mm
<b>Thickness Tolerances:</b>	±0.1mm	±0.05mm
<b>Surface Finish*:</b>	P2	P2 - P3
<b>Surface Quality (Scratch-Dig):</b>	80-50	20-10
<b>Flatness:</b>	2-3I	1/4
<b>Neutral Density:</b>	0.15 - 5.0 OD	
<b>Geometry:</b>	Round, Elliptical, and Rectangular	
<b>Filter Glass Type:</b>	Longpass, Shortpass, Bandpass, Neutral Density, and Combinations of Multiple Glasses	

\* Specifications per DIN ISO 10110. Manufacturing specifications per MIL-PRF-13830B also available.

## POLYMER POLARIZERS

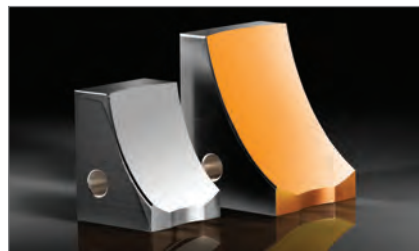


- Custom Polarizers Manufactured at our German Manufacturing Facility
- No Minimum Order Quantity

Linear Polarizer Manufacturing Capabilities*				
	Linear Polarizing Film	PMMA Laminated	Glass Laminated	Wire-Grid Polarizing Film
<b>Dimensions:</b>	3 x 3mm - 600 x 1000mm	3 x 3mm - 600 x 900mm	6 x 6mm - 250 x 250mm	3 x 3mm - 240 x 80mm
<b>Diameter:</b>	3 - 600mm	3 - 600mm	6 - 250mm	3 - 80mm
<b>Dimensional Tolerance:</b>	±0.20mm		±0.10mm	
<b>Thickness:</b>	0.18 - 0.75mm	1.00 - 3.00mm	2.00 - 3.50mm	0.08mm
<b>Transmission:</b>	Up to 44%			85%
<b>Extinction Ratio:</b>	Up to 1:30,000			1:4,250

\*For specifications for circular polarizers and retarders, visit [www.edmundoptics.com/capabilities/polarizers](http://www.edmundoptics.com/capabilities/polarizers)

## DIAMOND TURNING



- In-House Experts with 10+ Years' Experience
- Precision Diamond Turning of Metals, Crystalline Materials, and Plastics

Diamond Turning Capabilities			
	Commercial	Precision	High Precision
<b>Reflected Wavefront Error (P - V @ 632nm):</b>	λ	λ/2	λ/8
<b>Surface Quality:</b>	80-50	60-40	40-20
<b>Surface Roughness (RMS) Metals*:</b>	150Å	100Å	<30Å
<b>Surface Roughness (RMS): Crystalline Materials and Plastics</b>	<50Å for Diameters 6.25 - 200mm		
<b>Geometries:</b>	Off-Axis Parabolas, Off-Axis Ellipses, Off-Axis Toroids, Spherical Surfaces, Aspheric Surfaces, and Planar Surfaces		
<b>Angles:</b>	0 - 90°		
<b>Diameter (Off-Axis):</b>	2 - 254mm		
<b>Diameter (On-Axis):</b>	8 - 254mm		
<b>Coatings:</b>	Uncoated, Aluminum, UV Enhanced Aluminum, Protected Gold, Bare Gold, Protected Silver, Anti-Reflection, and Custom (upon request)		
<b>Materials:</b>	Metals (Aluminum, Copper, Brass, and Nickel-Plated Surfaces), Crystalline Materials (Germanium, Silicon, Calcium Fluoride, and Zinc Selenide), and Plastic (Acrylic and Zelonex)		

\*Exact values are dependent on the specific material and size

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