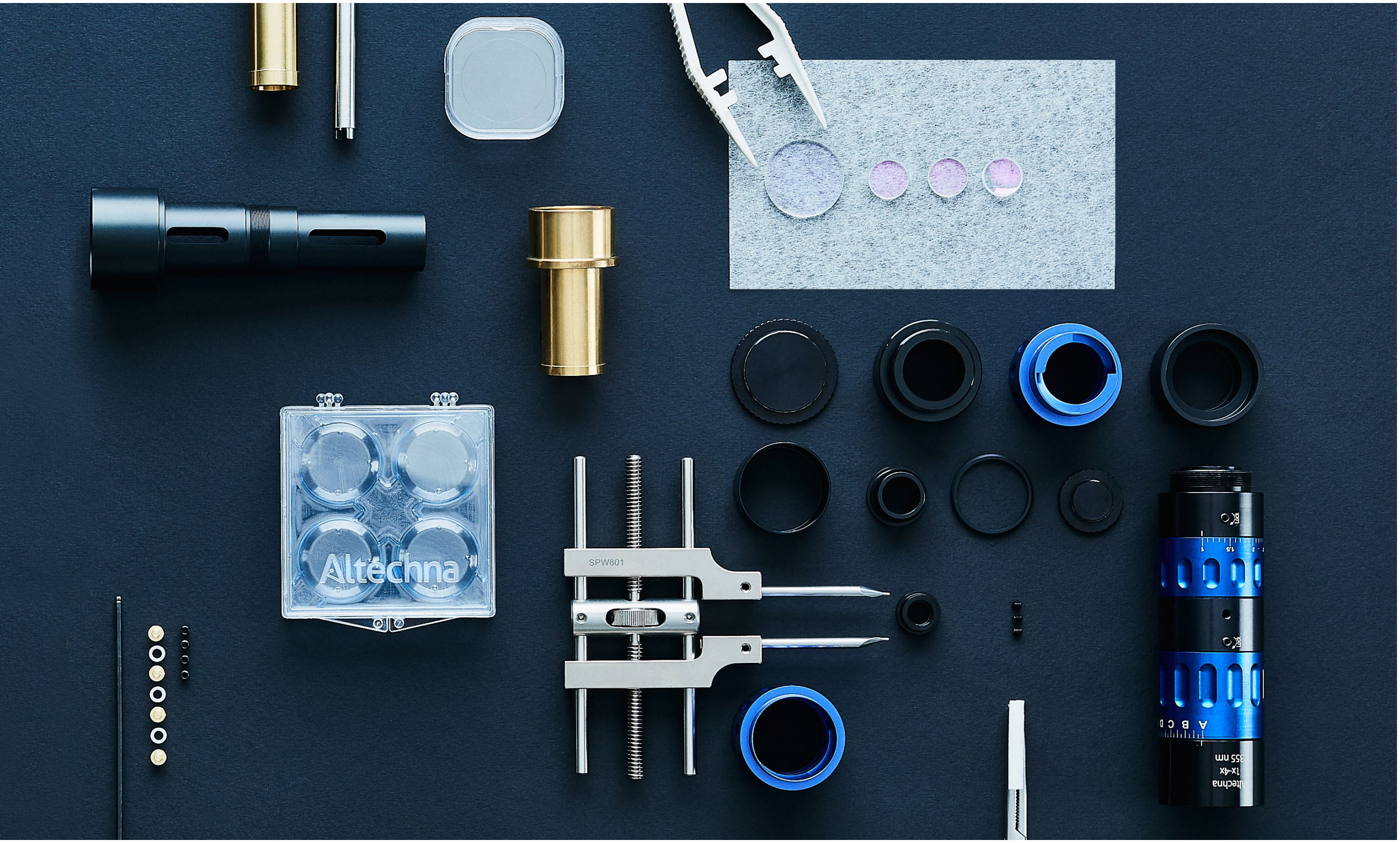
COMPONENTS FOR LASER BEAM DELIVERY



Altechna

A company you can rely on

Altechna is a Lithuania-based OEM manufacturer of high LIDT optical equipment – from optical coatings to motorized optomechanical assemblies. We have spent more than 25 years creating and developing complex technological solutions and custom designs for laser optics and related accessories.

Our in-depth knowledge on dielectric coatings and optical designs allows our industrial customers to reconsider their laser geometries and achieve even higher peak levels of power or reduce the weight of commercial products. From test batch to mass production, the quality and repeatability of each product are assured at our metrology laboratory. So, if your challenge involves anything from femtosecond to continuous-wave technology, we are here to support you with our innovative solutions.

Vision

We seek to become the go to source for custom made thin-film coatings, optical components and solutions for leading industrial and R&D institutions in selected photonics industries across the globe.

Mission

We adopt a fabless business strategy across global supply chain. We build and preserve key light technology knowledge and in-house expertise to serve our partner's needs best.

SPIE Corporate Member

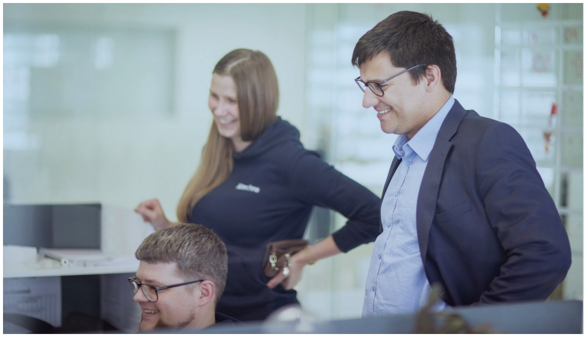
EPIC European Photonics Industry Consortium

OSA Corporate Associate Member

ISO 9001 BUREAU VERITAS Certification

RoHS Compliant

Why Altechna?

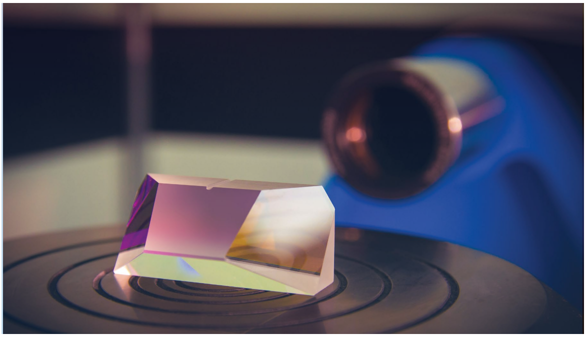


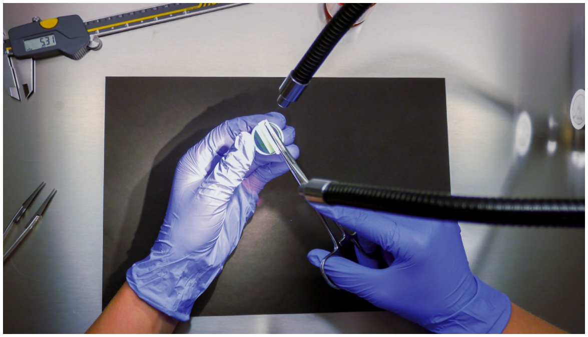
Professional Team

- Finest solutions to complex problems
- Technical consultations
- Fast reaction time
- High performance culture
- Validated supplier

Technological Capabilities

- In-house coating technologies
- Optomechanical engineering
- Custom optical designs
- Customer-defined optomechanical assemblies





Custom Laser Optics Solutions

- Laser optics
- Polarization optics
- Laser crystals
- Laser accessories

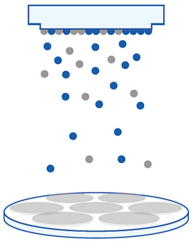
Quality Assurance

- LEAN manufacturing
- Copy-exactly!
- On time delivery
- Metrology laboratory

Technological Capabilities

Coating Technologies

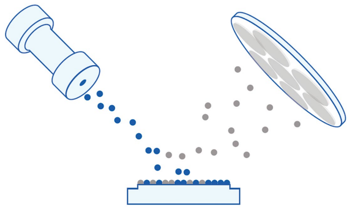
MAGNETRON SPUTTERING



Key features

- The best solution for mass production (~500 pcs of 1“ substrates)
- Plasma etching for higher LIDT
- Very low scattering and absorption losses
- Excellent solution for custom shape and size substrates
- Exceptional LIDT
- High contrast polarization coatings

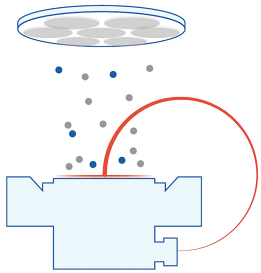
ION BEAM SPUTTERING



Key features

- Complex & long lifetime coatings
- Low absorption coatings
- Very high spectral coating accuracy
- Stress-controlled by complementary processes
- Excellent stability and performance in harsh environments

ELECTRON BEAM EVAPORATION + IAD



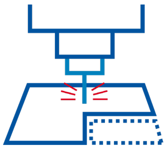
Key features

- Custom coatings design
- Low stress coatings
- Wide spectral range - from UV to IR
- High deposition rates
- Best cost - performance ratio

Markets We Serve

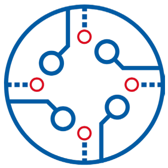
Altechna's wide variety of optical offerings allow us to provide the best solutions for our customers throughout multiple markets.

INDUSTRIAL (OEM)



Serving most sophisticated needs of companies leading in laser manufacturing and integration

SEMICON

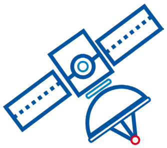


Combining various coating technologies with deep knowledge in laser-accessory manufacturing

MEDICAL

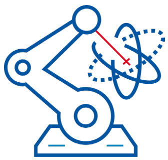
Mass production capabilities, high repeatability, fast customization, strict, multi-step quality control

SECURITY & DEFENSE



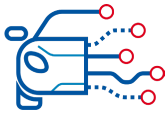
Ready to meet the highest standards of our security, defense and aerospace customers

SCIENCE / R&D



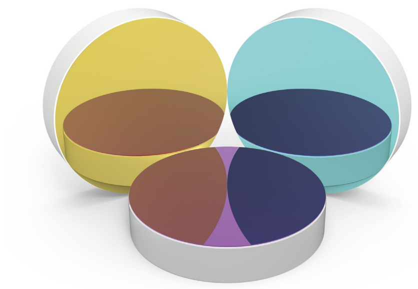
Time-tested solutions for a variety of research & development institutions

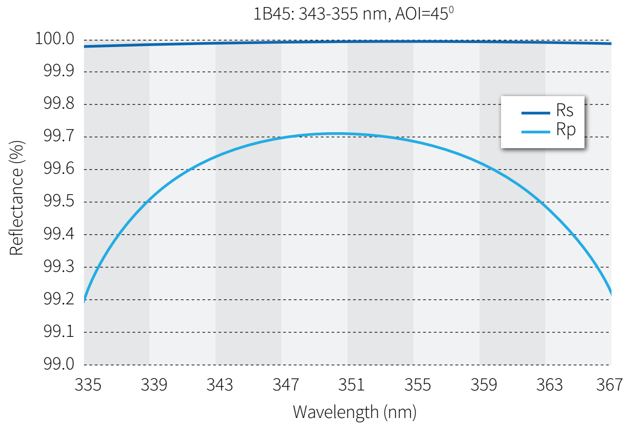
AUTOMOTIVE



Custom optics and subassembly solutions for various types of LiDAR

HR Laser Line Mirrors



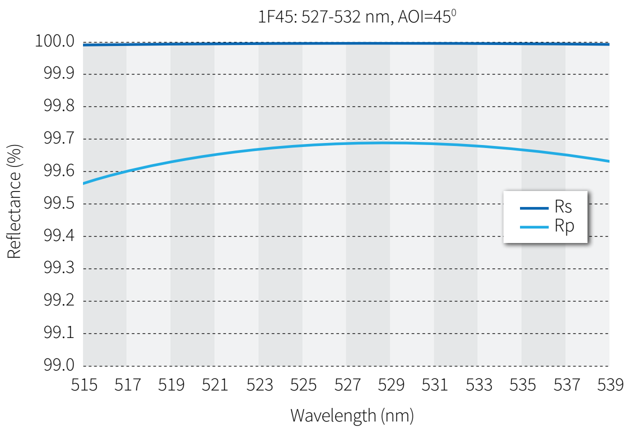


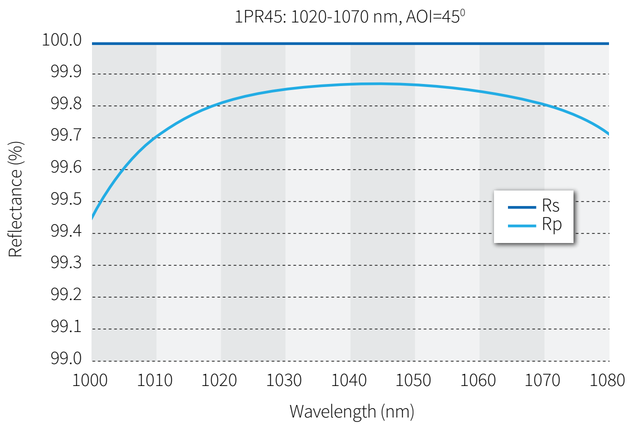
Description

Dielectric HR Laser Line Mirrors provide higher reflectivity values than metallic mirrors, making them a perfect choice for high-performance laser systems. HR mirrors can be optimized for certain wavelength, angle of incidence and polarization. We design mirrors in-house to meet your desired specifications and provide high-performance optics. Every coating batch is tested to confirm reflectivity values. Mirrors can also be optimized for high LIDT and LIDT measurements can be conducted upon request.

Features

- HR laser line coatings (HR) highly reflect at wavelength range of <10% of the central wavelength (CWL)
- Custom coatings are available for any wavelength in the range 0.19 - 5 µm
- Surface flatness, P-V: <λ/8 @ 632.8 nm
- Laser damage threshold up to 35.2 J/cm^2 @ 532 nm, 6.2 ns, 50 Hz



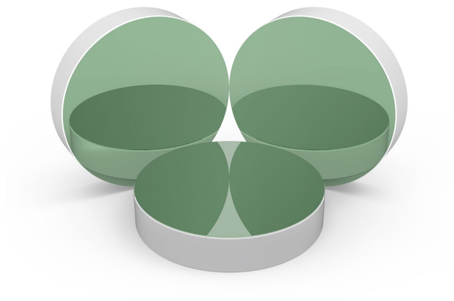


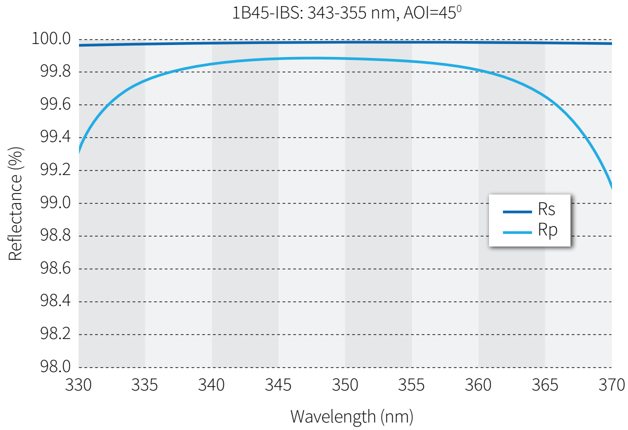
Typical Items*

Wavelength, nm	Reflectance s/p,%**	Substrate material	Product ID for AOI=45°, Ø25.4 mm
250-266	>99.0/>98.0	UVFS	1-OS-2-0254-5-[2AA45]
343-355	>99.5/>99.0	UVFS	1-OS-2-0254-5-[1B45]
380-420	>99.5/>99.0	UVFS	1-OS-2-0254-5-[1C45-GDD]
515	>99.5/>99.0	UVFS	1-OS-2-0254-5-[1E45]
527-532	>99.8/>99.3	BK7	1-OS-1-0254-6-[1F45]
760-840	>99.5/>99.0	UVFS	1-OS-2-0254-5-[1K45-GDD]
1030	>99.5/>99.0	UVFS	1-OS-2-0254-5-[1P45]
1020-1070	>99.8/>99.6	UVFS	1-OS-2-0254-5-[1PR45]
1047-1064	>99.5/>99.0	BK7	1-OS-1-0254-6-[1R45]
	Reflectance, %		**Product ID for AOI=0°, Ø25.4 mm**
343-355	>99.5	UVFS	1-OS-2-0254-5-[1B00]
760-840	>99.5	UVFS	1-OS-2-0254-5-[1K00-GDD]
1000-1060	>99.5	UVFS	1-OS-2-0254-5-[1P00]
1047-1064	>99.5	BK7	1-OS-1-0254-6-[1R00]

* Customized HR Laser Line Mirrors are available on request.
** “p” stands for value of reflected p polarization at 45°, “s” stands for value of reflected s polarization beam at 45°.

Low Loss HR Mirrors



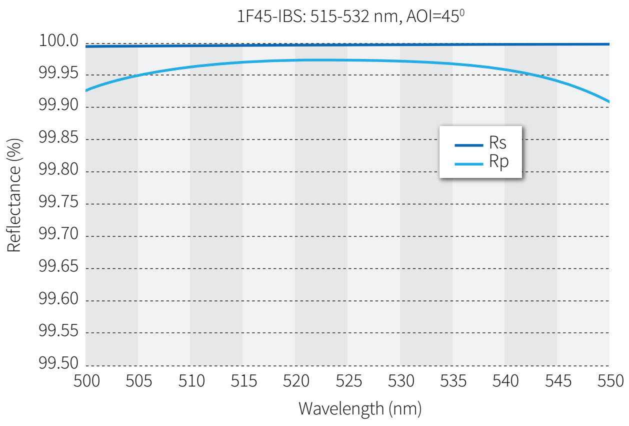


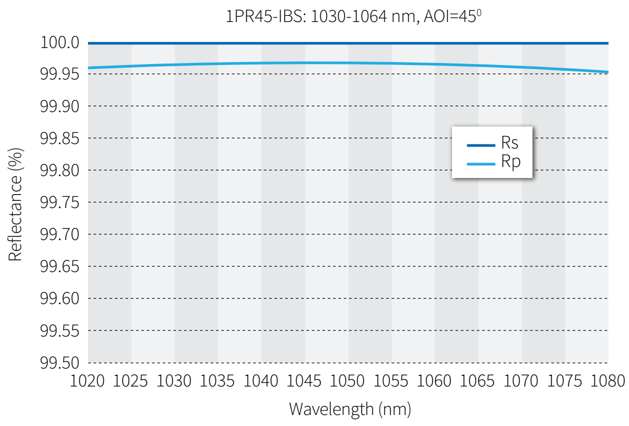
Description

Low Loss HR mirrors are essential in laser systems where the lowest possible losses are required. Mirrors are manufactured with advanced sputtering technology reach extremely high-quality specifications. Such thin films feature higher density and durability than e-beam coatings, making them resistant to environmental conditions such as heat, humidity and pressure. Mirrors reach highest reflectance (>99.9%) in a certain wavelength range and angles of incidence (AOI). Furthermore, scattering is minimized which is usually a limiting factor for high reflectivity.

Features

- Resistant to environmental conditions
- Wide-angle (AOI: 0-50°) mirrors are available
- Mass production capabilities: >500 pcs of Ø25.4 mm substrates per single batch
- Reflectance higher than 99.9%
- Typical surface flatness, P-V: <λ/8 @ 632.8 nm
- Laser damage threshold up to 17 J/cm^2 @ 1064 nm, 10 ns, 10 Hz



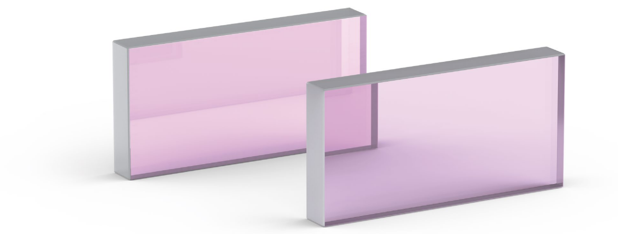


Typical Items*

Wavelength, nm	Reflectance, %	Substrate material	Dimensions, mm	Product ID for AOI=0°
515-532	>99.94	UVFS	Ø25.4x5	1-OS-2-0254-5-[1F00-IBS]
1030-1064	>99.95	UVFS	Ø25.4x5	1-OS-2-0254-5-[1PR00-IBS]
	Reflectance s/p, %			**Product ID for AOI=45°**
343-355	>99.9/>99.7	UVFS	Ø25.4x5	1-OS-2-0254-5-[1B45-IBS]
515-532	>99.97/>99.93	UVFS	Ø25.4x5	1-OS-2-0254-5-[1F45-IBS]
800	>99.97/>99.93	UVFS	Ø25.4x5	1-OS-2-0254-5-[1K45-IBS]
1030-1064	>99.97/>99.93	UVFS	Ø25.4x5	1-OS-2-0254-5-[1PR45-IBS]
1030-1064	>99.98/>99.93	UVFS	Ø30x5	1-OS-2-0300-5-[1PR45-IBS]
1550	>99.98/>99.93	BK7	Ø25.4x6	1-OS-1-0254-6-[1V45-IBS]
				Product ID for AOI=0°-45°
355	>99.9/>99.6	UVFS	Ø12.7x6	1-OS-2-0127-6-[1B45-IBS]-0-45
1027-1033	>99.9/>99.8	UVFS	Ø25.4x6	1-OS-2-0254-6-[1P45-IBS]-0-45

* Customized Low Loss HR Mirrors are available on request.
** “p” stands for value of reflected p polarization at 45°, “s” stands for value of reflected s polarization beam at 45°.

High Contrast Thin Film Polarizers



Description

High Contrast Thin Film Polarizers (TFP) are made using advanced Ion Beam Sputtering (IBS) coating technology. These thin film polarizers separate s- and p-polarization components of high energy laser beams. Due to very low losses they are perfect for intra and extra cavity usage. Because of their high damage threshold and extinction ratio (>1000:1), thin film polarizers are a good replacement for Glan laser polarizing prisms or polarizing cube beam splitters. For optimal performance, polarizers should be mounted in an appropriate holder allowing angular adjustment. We offer two types of high contrast polarizers: with higher LIDT or higher contrast values.

Features

- High Tp, low absorption & scattering
- No aging effects due to negligible porosity of the coatings
- Transmitted wavefront distortion (TWD), P-V: <λ/10 @ 632.8 nm
- Laser damage threshold up to 20 J/cm^2 @ 532 nm, 10 ns, 10 Hz (s-pol)

Typical Items*

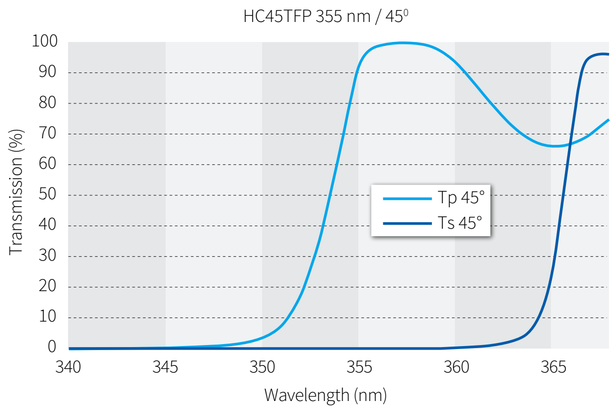
Wavelength, nm	Transmission, p-pol, %	Reflection, s-pol, %	Contrast, (Tp/Ts)	Typical LIDT @ 10 ns, 10 Hz for s-pol, J/cm^2	Typical LIDT @ 10 ns, 10 Hz for p-pol, J/cm^2	Product ID for AOI=Brewster
343	>97	>99.7	>300:1	>4	>1	2-HCBTFP-0343-0254
355	>97	>99.7	>300:1	>4	>1	2-HCBTFP-0355-0254
515	>99	>99.9	>1000:1	>5	>2	2-HCBTFP-0515-0254
532	>98	>99.8	>500:1	>7	>3	2-HCPBTFP-0532-0254
532	>99	>99.9	>1000:1	>5	>2	2-HCBTFP-0532-0254
800	>99	>99.9	>1000:1	>7	>3	2-HCBTFP-0800-0254
1030	>99	>99.8	>500:1	>20	>10	2-HCPBTFP-1030-1020
1030	>99	>99.9	>1000:1	>7	>3	2-HCBTFP-1030-0254
1064	>99	>99.8	>500:1	>20	>10	2-HCPBTFP-1064-1020
1064	>99	>99.9	>1000:1	>7	>3	2-HCBTFP-1064-0254

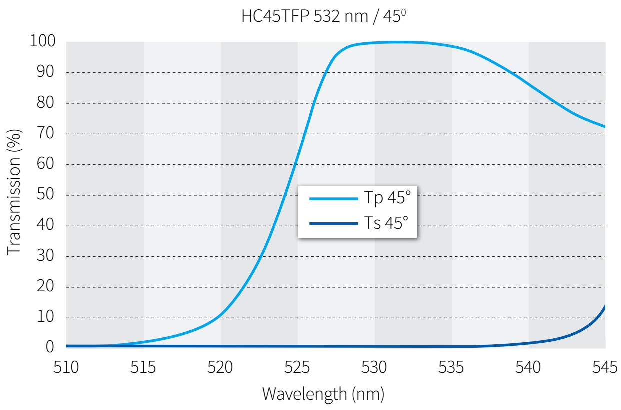
* Customized solutions are available on request. Typical dimensions are Ø25.4 x 5 mm, 20 x 40 x 5 mm and 10 x 20 x 5 mm.

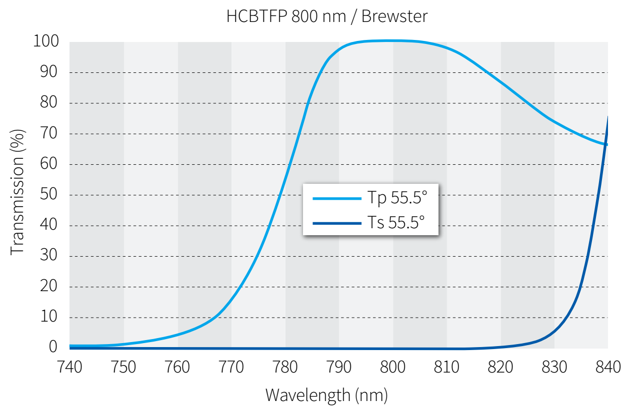
Typical Items*

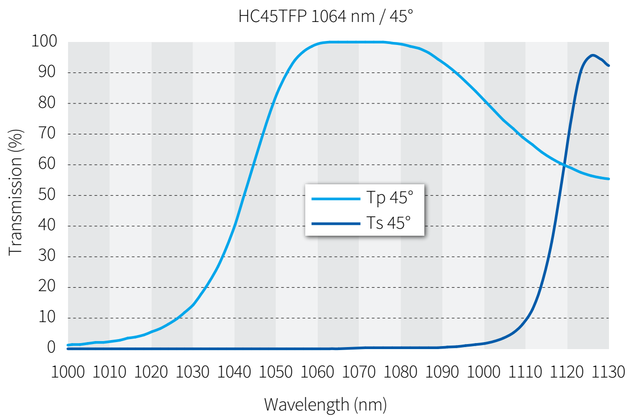
Wavelength, nm	Transmission, p-pol, %	Reflection, s-pol, %	Contrast, (Tp/Ts)	Typical LIDT @ 10 ns, 10 Hz for s-pol, J/cm²	Typical LIDT @ 10 ns, 10 Hz for p-pol, J/cm²	Product ID for AOI=45°
355	>95	>99.8	>500:1	>4	>1	2-HC45TFP-0355-0254
532	>98	>99.8	>500:1	>7	>3	2-HCP45TFP-0532-0254
532	>97	>99.9	>1000:1	>5	>2	2-HC45TFP-0532-0254
1030	>97	>99.8	>500:1	>20	>10	2-HCP45TFP-1030-0254
1030	>97	>99.8	>1000:1	>7	>3	2-HC45TFP-1030-0254
1064	>97	>99.8	>500:1	>20	>10	2-HCP45TFP-1064-0254
1064	>97	>99.9	>1000:1	>7	>3	2-HC45TFP-1064-0254

* Customized solutions are available on request. Typical dimensions are Ø25.4 x 5 mm, 20 x 40 x 5 mm and 10 x 20 x 5 mm.

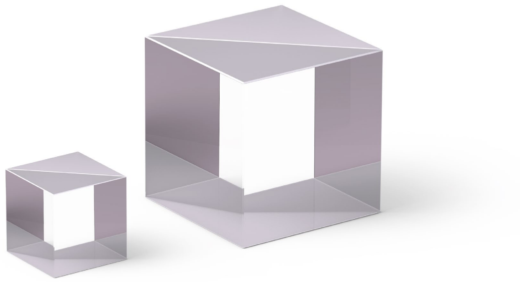








Polarizing Cubes for High Energy Applications



Description

Polarizing beamsplitter cubes offer several advantages over plate beamsplitters. They are easy to handle, high contrast and high extinction ratio polarizers that split a randomly polarized beam into two orthogonal linearly polarized components. These products are typically used in laser-beam separation, combination and optical-isolation applications. The epoxy-free construction of the cubes enables a superior performance at high energy levels.

Features

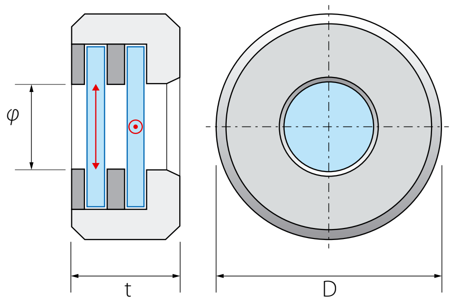
- Easy, deformation-free mounting
- High extinction ratio in transmission: Tp/Ts >1000:1
- Low reflected and transmitted wavefront distortion, P-V: <λ/10 @ 632.8 nm
- No ghost reflections
- Minimal beam displacement
- Negligible absorption of reflected and transmitted beams
- High transmission of p-polarization: Tp > 97%
- No material fluorescence in UV region
- Laser damage threshold up to 20 J/cm^2 @ 1064 nm, 10 ns, 100 Hz

Typical Items*

Wavelength, nm	Dimensions, mm	Reflection s-pol, %	Transmission p-pol, %	Product ID
345-365 (centered @ 355)	12.7x12.7x12.7	>99.5	>96	2-HPCB-A-0125
	25.4x25.4x25.4	>99.5	>96	2-HPCB-A-0254
510-550 (centered @ 532)	12.7x12.7x12.7	>99.5	>97	2-HPCB-B-0125
	25.4x25.4x25.4	>99.5	>97	2-HPCB-B-0254
1020-1090 (centered @ 1064)	12.7x12.7x12.7	>99.5	>97	2-HPCB-C-0125
	25.4x25.4x25.4	>99.5	>97	2-HPCB-C-0254
1510-1580 (centered @ 1550)	12.7x12.7x12.7	>99.5	>97	2-HPCB-D-0125

* Customized solutions are available on request.

Crystalline Quartz Waveplates



Features

- High extinction ratio
- Wide wavelength range
- Low transmitted wavefront distortion
- High LIDT

Description

Crystalline quartz waveplates are made from materials that have a birefringence property. Most common types are designed so that an ordinary ray will exhibit a half (λ/2) or quarter (λ/4) wave retardation with respect to an extraordinary ray. Such waveplates are used to rotate the plane of polarization, converting a linear polarization to a circular one and vice versa. Such elements are used for electro-optic modulations and as a variable ratio beamsplitter when used in conjunction with a polarization cube. Although the latter two types of waveplates are the most common, Altechna also offers custom retardation values on request.

One of the most common arrangements of the waveplates is the zero order (ZO) air-spaced version. These waveplates are built of two crystalline quartz plates with specific thicknesses and crossed axes, which results in a zero order performance. This arrangement allows us to reach a better performance for a wider wavelength range and is less sensitive to temperature changes when compared with low order (LO) waveplates. High purity crystalline quartz materials and precise parallelism between the two air-spaced plates allows the transmitted wavefront distortion to be better than λ/10 at 632.8 nm.

Typical Items Ø12.7 x 6 mm

ZO Crystalline Quartz Waveplates (air-spaced)		
Wavelength, nm	**Product ID**	
	λ/2 retardation, clear aperture >8 mm	**λ/4 retardation, clear aperture >8 mm**
343	2-CPW-ZO-L2-0343-S	2-CPW-ZO-L4-0343-S
355	2-CPW-ZO-L2-0355-S	2-CPW-ZO-L4-0355-S
400	2-CPW-ZO-L2-0400-S	2-CPW-ZO-L4-0400-S
515	2-CPW-ZO-L2-0515-S	2-CPW-ZO-L4-0515-S
532	2-CPW-ZO-L2-0532-S	2-CPW-ZO-L4-0532-S
800	2-CPW-ZO-L2-0800-S	2-CPW-ZO-L4-0800-S
1030	2-CPW-ZO-L2-1030-S	2-CPW-ZO-L4-1030-S
1064	2-CPW-ZO-L2-1064-S	2-CPW-ZO-L4-1064-S

Typical Items Ø25.4 x 6 mm

ZO Crystalline Quartz Waveplates (air-spaced)		
Wavelength, nm	**Product ID**	
	λ/2 retardation, clear aperture >18 mm	**λ/4 retardation, clear aperture >18 mm**
266	2-CPW-ZO-L2-0266-W	2-CPW-ZO-L4-0266-W
343	2-CPW-ZO-L2-0343-W	2-CPW-ZO-L4-0343-W
355	2-CPW-ZO-L2-0355-W	2-CPW-ZO-L4-0355-W
400	2-CPW-ZO-L2-0400	2-CPW-ZO-L4-0400
515	2-CPW-ZO-L2-0515	2-CPW-ZO-L4-0515
532	2-CPW-ZO-L2-0532	2-CPW-ZO-L4-0532
633	2-CPW-ZO-L2-0633	2-CPW-ZO-L4-0633
780	2-CPW-ZO-L2-0780	2-CPW-ZO-L4-0780
800	2-CPW-ZO-L2-0800	2-CPW-ZO-L4-0800
852	2-CPW-ZO-L2-0852	2-CPW-ZO-L4-0852
1030	2-CPW-ZO-L2-1030	2-CPW-ZO-L4-1030
1064	2-CPW-ZO-L2-1064	2-CPW-ZO-L4-1064
1550	2-CPW-ZO-L2-1550	2-CPW-ZO-L4-1550

* Customized solutions are available on request.

High Energy Waveplates

Description

Altechna provides standard (air-spaced) and high power (optically bonded) waveplates. They are made from materials that has a birefringence property. Most common types are designed so ordinary ray would exhibit half (λ/2) or quarter (λ/4) wave retardation with respect to an extraordinary one. Such waveplates are used to rotate the plane of polarization, convert linear polarization to circular and vice versa. Such elements are used for electro-optic modulation and as a variable ratio beamsplitter, when used in conjunction with a polarization cube. Although latter two types of waveplates are the most common, Altechna offers custom retardation values on request.

Features

- High extinction ratio
- Wide acceptance angle
- Wide temperature bandwidth
- Exceptional durability in UV applications
- Wide wavelength range available

Typical Items*

Wavelength, nm	Product ID		
	Mount size Ø12.7 x 6 mm	**Mount size Ø25.4 x 6 mm**	**Mount size Ø25.4 x 6 mm**
	λ/2 retardation, clear aperture >8 mm	**λ/2 retardation, clear aperture >18 mm**	**λ/4 retardation, clear aperture >18 mm**
266		2-CPW-TSO-L2-0266	2-CPW-T4O-L4-0266-W
343	2-CPW-TFO-L2-0343-S	2-CPW-TFO-L2-0343-W	2-CPW-TTO-L4-0343-W
355	2-CPW-TFO-L2-0355-S	2-CPW-TFO-L2-0355-W	2-CPW-TSO-L4-0355-W
400	2-CPW-TFO-L2-0400-S	2-CPW-TFO-L2-0400	2-CPW-TSO-L4-0400
515	2-CPW-TZO-L2-0515-S	2-CPW-TFO-L2-0515	2-CPW-TSO-L4-0515
532	2-CPW-TZO-L2-0532-S	2-CPW-TFO-L2-0532	2-CPW-TFO-L4-0532
780			2-CPW-TFO-L4-0780
800	2-CPW-TZO-L2-0800-S	2-CPW-TZO-L2-0800	2-CPW-TFO-L4-0800
1030	2-CPW-TZO-L2-1030-S	2-CPW-TZO-L2-1030	2-CPW-TFO-L4-1030
1064	2-CPW-TZO-L2-1064-S	2-CPW-TZO-L2-1064	2-CPW-TFO-L4-1064
1550	2-CPW-TZO-L2-1550-S	2-CPW-TZO-L2-1550	2-CPW-TZO-L4-1550

* Customized solutions are available on request.

PowerXP Motorized Attenuators

Description

Altechna offers four types of laser beam intensity attenuators for high energy applications:

- CA 8 mm – Compact version
- CA 18 mm – Maxi Reflection/Transmission version
- CA 18 mm – Maxi Transmission Collinear version
- CA 18 mm – Maxi Cube version

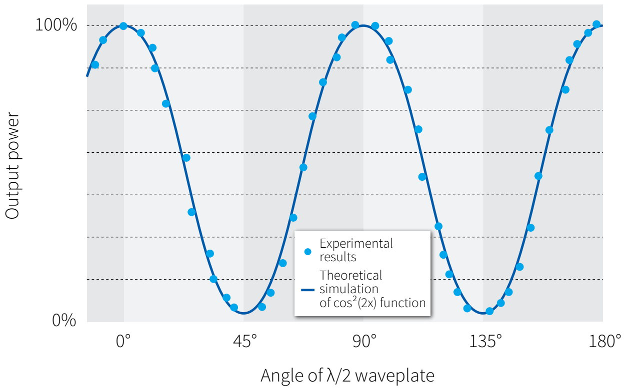
Watt Pilot attenuators. New generation PXP units have upgraded belt-driven rotator mechanism for quick and precise laser beam intensity control and also brand new electronics and control driver for more connectivity options and reliable long-distance communication.

PowerXP motorized attenuators are a reliable solution for industrial applications. Each attenuator includes motorized rotating quartz λ/2 phase waveplate, optically aligned to a single/dual thin film polarizers or polarizing beamsplitting cube which separates the input beam into individual s-polarized and p-polarized parallel or perpendicular output beams.

Special PowerXP Transmission Collinear version includes an additional uncoated UVFS window positioned at Brewster angle after the polarizer to compensate the lateral beam shift caused by polarizing plate and guarantees less than 100 µm radial beam displacement between input and output laser beam for ultra-precise applications.

High energy applications compatible optics, fast rotation speed of PowerXP Maxi version, compensated beam displacement output of Maxi Collinear version, convenient polarization separation angle of Maxi Cube version and small footprint of Compact version makes PowerXP motorized attenuators a go-to solution for power control, attenuation, and beam-splitting in demanding laser processing applications.

Example of performance provided by attenuator comprising a waveplate and a polarizer.



Features

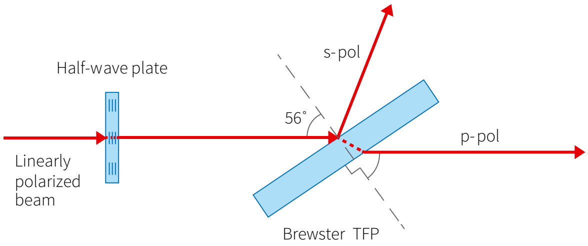
- User-friendly software interface, USB, RS232, Ethernet connection
- Divides laser beam into two s-pol and p-pol beams of adjustable intensity ratio
- Low dispersion optics for ultrashort and high energy laser pulses
- Ideal for integration into other systems
- Time between min and max attenuation less than 0.2 sec

Compact version

Standard specifications

Clear aperture	Ø8 mm
Recommended maximum input beam diameter at $1/e^2$	Ø5 mm
Bandwidth	±5 nm, up to ±10 on request
Optimization	Transmission type
Configuration	λ/2 Optically bonded waveplate + IBS technology High Contrast Thin Film Polarizer
Attenuation range* @ CWL	From <0.1% to >99%
Typical applications	High power pulsed and CW lasers
Damage threshold	Up to >20 J/cm^2 @ 1064 nm, 10 ns, 10 Hz
Dimensions H x L x W	35 x 55 x 60 mm
Time between min and max attenuation	<0.2 sec
Steps between min and max attenuation	14400
Resolution	<11.25 arcsec/step
Maximum power transmission	T_{max} >99% at p-pol output
Maximum power blocking	T_{min} <0.1% at p-pol output
*Optional attenuation range	T_{max} >99.7%, T_{min}<4% at s-pol beam dump output

Transmission type



Typical Items

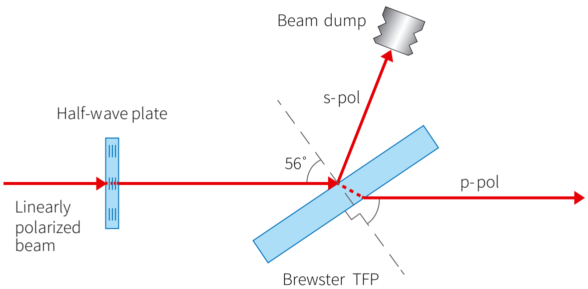
Wavelength, nm	Bandwidth, nm	Configuration	Optimization	Attenuation range at p-pol output (T_{min}-T_{max}) @ CWL	Product ID
343	±5	λ/2 Optically bonded waveplate + HCTFP	Transmission	0.3-96%	PXP-08-0343
355	±5	λ/2 Optically bonded waveplate + HCTFP	Transmission	0.3-96%	PXP-08-0355
515	±5	λ/2 Optically bonded waveplate + HCTFP	Transmission	0.1-99%	PXP-08-0515
532	±5	λ/2 Optically bonded waveplate + HCTFP	Transmission	0.1-99%	PXP-08-0532
1030	±5	λ/2 Optically bonded waveplate + HCTFP	Transmission	0.1-99%	PXP-08-1030
1064	±5	λ/2 Optically bonded waveplate + HCTFP	Transmission	0.1-99%	PXP-08-1064

Maxi Transmission version

Standard specifications

Clear aperture	Ø18 mm
Recommended maximum input beam diameter at $1/e^2$	Ø12 mm
Bandwidth	±5 nm, up to ±10 on request
Optimization	Transmission (“T” model)
Configuration	λ/2 Air-spaced or Optically bonded waveplate + Thin Film Polarizer
Attenuation range* @ CWL	From <0.5% to >95%
Typical applications	High power pulsed and CW lasers
Damage threshold	Up to >10 J/cm^2 @ 1064 nm, 10 ns, 10 Hz
Dimensions H x L x W	56 x 99 x 90 mm
Time between min and max attenuation	<0.2 sec
Steps between min and max attenuation	24000
Resolution	<7 arcsec/step
Maximum power transmission	T_{max} >95% at p-pol output
Maximum power blocking	T_{min} <0.5% at p-pol output
Integrated beam dump power limit	15 W
*Optional attenuation range	T_{max} >99.5%, T_{min}<5% at s-pol beam dump

Transmission type



Typical Items

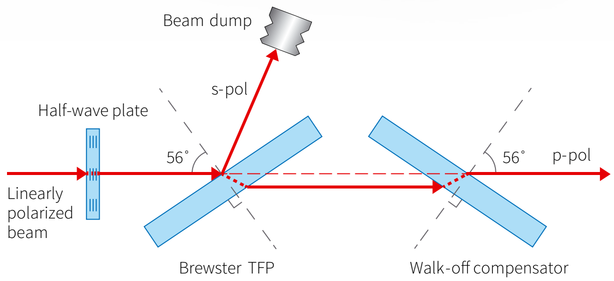
Wavelength, nm	Bandwidth, nm	Configuration	Optimization	Attenuation range at p-pol output (T_{min}-T_{max}) @ CWL	Product ID
266	±5	λ/2 Optically bonded waveplate + TFP	Transmission	0.5-95%	PXP-18-T-0266
343	±5	λ/2 Optically bonded waveplate + TFP	Transmission	0.5-95%	PXP-18-T-0343
355	±5	λ/2 Optically bonded waveplate + TFP	Transmission	0.5-95%	PXP-18-T-0355
515	±5	λ/2 Air-spaced waveplate + TFP	Transmission	0.5-95%	PXP-18-T-0515
532	±5	λ/2 Air-spaced waveplate + TFP	Transmission	0.5-95%	PXP-18-T-0532
1030	±10	λ/2 Air-spaced waveplate + TFP	Broadband Transmission	0.5-95%	PXP-18-T-1030
1064	±5	λ/2 Air-spaced waveplate + TFP	Transmission	0.5-95%	PXP-18-T-1064

Maxi Collinear version

Standard specifications

Clear aperture	Ø18 mm
Recommended maximum input beam diameter at $1/e^2$	Ø12 mm
Bandwidth	±5 nm, up to ±10 on request
Optimization	Transmission type with lateral beam shift compensation (“CL” model)
Configuration	λ/2 Air-spaced or Optically bonded waveplate + TFP and Compensating Window
Attenuation range @ CWL	From <0.5% to >95%
Typical applications	High power pulsed and CW lasers
Damage threshold	Up to >10 J/cm² @ 1064 nm, 10 ns, 10 Hz
Dimensions H x L x W	56 x 144 x 90 mm
Time between min and max attenuation	<0.2 sec
Steps between min and max attenuation	24000
Resolution	<7 arcsec/step
Maximum power transmission	T_{max} >95% at p-pol output
Maximum power blocking	T_{max} <0.5% at p-pol output
Integrated beam dump power limit	15 W

Collinear type



Typical Items

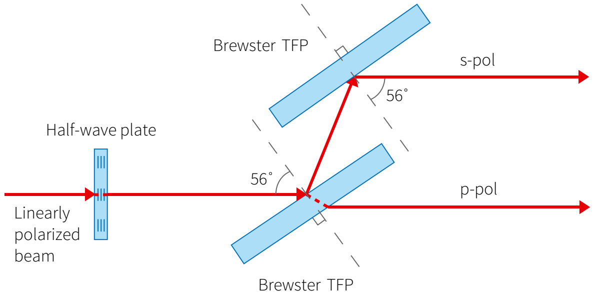
Wavelength, nm	Bandwidth, nm	Configuration	Optimization	Attenuation range at p-pol output (T_{min}-T_{max}) @ CWL	Product ID
343	±5	λ/2 Optically bonded waveplate + TFP + compensating window	Transmission	0.5-95%	PXP-18-CL-0343
355	±5	λ/2 Optically bonded waveplate + TFP + compensating window	Transmission	0.5-95%	PXP-18-CL-0355
515	±5	λ/2 Air-spaced + TFP + compensating window	Transmission	0.5-95%	PXP-18-CL-0515
532	±5	λ/2 Air-spaced + TFP + compensating window	Transmission	0.5-95%	PXP-18-CL-0532
1030	±10	λ/2 Air-spaced + TFP + compensating window	Transmission	0.5-95%	PXP-18-CL-1030
1064	±5	λ/2 Air-spaced + TFP + compensating window	Transmission	0.5-95%	PXP-18-CL-1064

Maxi Reflection version

Standard specifications

Clear aperture	Ø18 mm
Recommended maximum input beam diameter at $1/e^2$	Ø12 mm
Bandwidth	±5 nm, up to ±10 on request
Optimization	Reflection ("R" model)
Configuration	λ/2 Air-spaced or Optically bonded waveplate + 2x Thin Film Polarizers
Attenuation range* @ CWL	From <0.3% to >99%
Typical applications	High power pulsed and CW lasers
Damage threshold	Up to >10 J/cm^2 @ 1064 nm, 10 ns, 10 Hz
Dimensions H x L x W	56 x 99 x 90 mm
Time between min and max attenuation	<0.2 sec
Steps between min and max attenuation	24000
Resolution	<7 arcsec/step
Maximum power transmission	T_{max} >99% at s-pol output
Maximum power blocking	T_{min} <0.3% at s-pol output
*Optional attenuation range	T_{max} >95%, T_{min}<0.5% at p-pol output

Reflection type



Typical Items

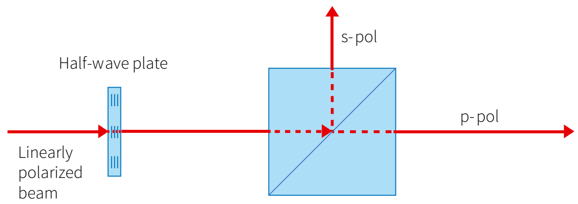
Wavelength, nm	Bandwidth, nm	Configuration	Optimization	Attenuation range at s-pol output (T_{min}-T_{max}) @ CWL	Product ID
266	±5	λ/2 Optically bonded waveplate + 2x TFP	Reflection	0.3-99%	PXP-18-R-0266
343	±5	λ/2 Optically bonded waveplate + 2x TFP	Reflection	0.3-99%	PXP-18-R-0343
355	±5	λ/2 Optically bonded waveplate + 2x TFP	Reflection	0.3-99%	PXP-18-R-0355
515	±5	λ/2 Air-spaced waveplate + 2x TFP	Reflection	0.3-99%	PXP-18-R-0515
532	±5	λ/2 Air-spaced waveplate + 2x TFP	Reflection	0.3-99%	PXP-18-R-0532
1030	±10	λ/2 Air-spaced waveplate + 2x TFP	Broadband reflection	0.3-99%	PXP-18-R-1030
1064	±5	λ/2 Air-spaced waveplate + 2x TFP	Reflection	0.3-99%	PXP-18-R-1064

Maxi Cube version

Standard specifications

Clear aperture	Ø18 mm
Recommended maximum input beam diameter at $1/e^2$	Ø12 mm
Bandwidth	±5 nm, up to ±10 on request
Optimization	Transmission and Reflection
Configuration	λ/2 Air-spaced or Optically bonded waveplate + Optically bonded PBS cube
Attenuation range @ CWL	From <0.3% to 97% in transmission mode
	From <3% to 99% in reflection mode
Typical applications	High power pulsed and CW lasers
Damage threshold	Up to >10 J/cm^2 @ 1064 nm, 10 ns, 10 Hz
Dimensions H x L x W	56 x 82 x 90 mm
Time between min and max attenuation	<0.2 sec
Steps between min and max attenuation	24000
Resolution	<7 arcsec/step
Transmission mode:	
Maximum power transmission	T_{max} >97% at p-pol output
Maximum power blocking	T_{min}<0.3% at p-pol output
Reflection mode:	
Maximum power transmission	T_{max} >99% at s-pol output
Maximum power blocking	T_{min}<3% at s-pol output

Cube type



Typical Items

Wavelength, nm	Bandwidth, nm	Configuration	Attenuation range at p-pol output (T_{min}-T_{max}) @ CWL	Attenuation range at s-pol output (T_{min}-T_{max}) @ CWL	Product ID
355	±5	λ/2 Optically bonded waveplate + Optically bonded PBS cube	0.3-96%	4-99%	PXP-18-C-0355
515	±5	λ/2 Air-spaced waveplate + Optically bonded PBS cube	0.3-97%	3-99%	PXP-18-C-0515
532	±5	λ/2 Air-spaced waveplate + Optically bonded PBS cube	0.3-97%	3-99%	PXP-18-C-0532
1030	±5	λ/2 Air-spaced waveplate + Optically bonded PBS cube	0.3-97%	3-99%	PXP-18-C-1030
1064	±5	λ/2 Air-spaced waveplate + Optically bonded PBS cube	0.3-97%	3-99%	PXP-18-C-1064

Fixed Ratio Beam Expanders

Description

Fixed ratio beam expander is a device dedicated to increase the diameter of a laser beam.

Altechna's beam expanders are assembled using one diverging and one converging lens. As there is no focal point inside of the beam expander, it can be used with high power laser sources. Special treatment of lenses and mechanics is performed for UV application to improve lifetime and LIDT of the expander. Standard magnifications are from 1.1x to 5x. Beam expanders for any wavelengths between 266 – 1064 nm are available upon request.

Features

- Custom magnification and design on request
- Extended lifetime and LIDT for UV applications
- Individual reports of beam ellipticity, M^2 and pointing stability parameters
- Custom wavelengths are available in the range of 266-1064 nm

Standard specifications

Lens material	UVFS
Transmitted wavefront distortion	<λ/4 @ 632.8 nm
Overall transmission	>98%
LIDT	>10 J/cm² @ 1064 nm, 10 ns, 10 Hz
Housing material	Clear anodized
Mounting thread	SM1

Typical Items

Wavelength, nm	Expansion	Max input beam diameter*, mm	Housing dimensions, mm	Product ID
343-355	1.2x	10	Ø30 x 56.6	FBE-1.2X-0343-0355
	1.5x	8.5	Ø30 x 55.7	FBE-1.5X-0343-0355
	2x	5	Ø30 x 58.1	FBE-2X-0343-0355
	2.5x	5	Ø30 x 79.4	FBE-2.5X-0343-0355
	3x	5	Ø30 x 56.6	FBE-3X-0343-0355
	4x	4	Ø30 x 80.1	FBE-4X-0343-0355
	5x	3	Ø30 x 85.1	FBE-5X-0343-0355
515-532	1.2x	10	Ø30 x 58.2	FBE-1.2X-0515-0532
	1.5x	9	Ø30 x 57.3	FBE-1.5X-0515-0532
	2x	6	Ø30 x 59.6	FBE-2X-0515-0532
	2.5x	6	Ø30 x 78.8	FBE-2.5X-0515-0532
	3x	4.5	Ø30 x 58.2	FBE-3X-0515-0532
	4x	4	Ø30 x 81.7	FBE-4X-0515-0532
	5x	3	Ø30 x 87.6	FBE-5-0515-0532
1020-1070	1.2x	10	Ø30 x 59.4	FBE-1.2X-1030-1064
	1.5x	10	Ø30 x 58.4	FBE-1.5X-1030-1064
	2x	6	Ø30 x 60.8	FBE-2X-1030-1064
	2.5x	6	Ø30 x 80.6	FBE-2.5X-1030-1064
	3x	5	Ø30 x 59.4	FBE-3X-1030-1064
	4x	4.5	Ø30 x 82.9	FBE-4X-1030-1064
	5x	3.5	Ø30 x 87.5	FBE-5X-1030-1064

* Max input beam diameter at $1/e^2$ ensuring diffraction limited performance.

Variable Beam Expanders

Features

- Individual reports of beam ellipticity, M^2 and pointing stability parameters
- Mounting adapters at the input, output and middle are available on request
- Extended lifetime and LIDT for UV applications
- High overall system LIDT: >6.5 J/cm^2 @ 1064 nm, 10 ns, 100 Hz for 1x-4x model

Description

Variable beam expanders are ideal for systems in which different magnifications and precise control of laser beam divergence are required. Altechna offers Galilean type variable beam expanders with high LIDT AR coatings that minimize ghost reflections. Our variable beam expanders allow individual magnification and divergence adjustment. Two main standard products change magnification in the range of 1x-4x and 2x-8x.

Standard specifications

Wavelength range	266 – 1064 nm
Expansions	1x-4x or 2x-8x
Pointing stability	<1 mrad
Lens material	UVFS
Transmitted wavefront distortion, P-V	<λ/4 @ 632.8 nm
Overall transmission	>97% (>99% on request)
Mounting thread (input side)	SM1
Mounting thread (output side, on request)	M42 x 1.5 (outer), SM1 (inner)
LIDT for 2x-8x model	>5 J/cm2 @ 1064 nm, 10 ns, 100 Hz
LIDT for 1x-4x model	>6.5 J/cm2 @ 1064 nm, 10 ns, 100 Hz

Typical Items

Wavelength, nm	Expansion range	Max input beam diameter*, mm	Product ID
343-355	1x-4x	1x - 4.0 2x - 5.5 3x - 3.0 4x - 3.0	VBE-1X-4X-0343-0355-B
	2x-8x	2x - 5.0 3x - 5.0 4x - 4.0 5x - 3.0 6x - 2.5 7x - 2.25 8x - 2.0	VBE-2X-8X-0343-0355-B-2M

* Max input beam diameter at $1/e^2$ ensuring diffraction limited performance.

Typical Items

Wavelength, nm	Expansion range	Max input beam diameter*, mm	Product ID
515-532	1x-4x	1x - 4.5 2x - 6.5 3x - 4.0 4x - 4.0	VBE-1X-4X-0515-0532-B
	2x-8x	2x - 5.0 3x - 5.0 4x - 4.0 5x - 3.0 6x - 2.5 7x - 2.25 8x - 2.0	VBE-2X-8X-0515-0532-B-2M
1030-1064	1x-4x	1x - 4.5 2x - 7.0 3x - 5.0 4x - 4.0	VBE-1X-4X-1030-1064-B
	2x-8x	2x - 5.0 3x - 5.0 4x - 5.0 5x - 4.0 6x - 3.0 7x - 2.5 8x - 2.5	VBE-2X-8X-1030-1064-B-2M

* Max input beam diameter at $1/e^2$ ensuring diffraction limited performance.

Motorized Beam Expanders

Features:

- High pointing stability: <100 µrad
- High expansion repeatability: ±0.6%
- Long service life: >3.6 million cycles
- Suitable for high power applications

Description

Motorized Beam Expander (MBE) is a precision beam expander designed for automated applications. Device allows rapid and independent divergence as well as magnification adjustment during its operation. MBE features high pointing stability as well as expansion accuracy. ±61 µm focal plane deviation is ensured for 1x-2x model after warp-up using +160 mm focal length F-theta lens and Ø4.9 mm input beam.

Moreover, high expansion repeatability and longevity of the product help to increase the efficiency of the application as frequent calibration and replacement can be avoided. In addition, MBE optical design enables it to be used in high power laser applications as there are no internal foci.

Standard specifications

Expansion ranges	1x-2x, 1x(1.1x)*-5.5x
Pointing stability	<100 µrad
24/7 expansion repeatability	±0.6%
Expansion accuracy	<±7.5% (1x-2x model)
	<±5% (1x(1.1x)-5.5x model)
Operation speed	<1 sec from min to max
Suitable for long beam path	>2 meters propagation
Minimum service life	>3500 hours of non-stop operation
Transmittance	>98% (> 99% on request)
Control interfaces	RS232, USB, LAN

*515-532 nm and 1030-1064 nm models are limited to 1.1x-5.5x range.

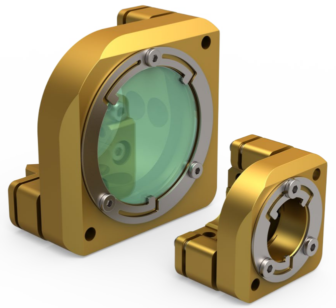
Typical Items

Magnification	**Wavelength, nm**	**Max input beam diameter*, mm**	**LIDT, J/cm^2 @ 10 ns, 100 Hz**	**Product ID**
1x-2x	343-355	1X - Ø7.5 1.5X - Ø5.5 2X - Ø4.5	>3.1	MBE-1X-2X-0343-0355-v.3.4.3
1x-2x	515-532	1X - Ø8.0 1.5X - Ø6.5 2X - Ø5.0	>3.5	MBE-1X-2X-0515-0532-v.3.4.3
1x-2x	1030-1064	1X - Ø9.5 1.5X - Ø8.0 2X - Ø6.5	>8.8	MBE-1X-2X-1030-1064-v.3.4.3

Magnification	Wavelength, nm	Max input beam diameter*, mm	LIDT, J/cm² @ 10 ns, 100 Hz	Product ID
1x-5.5x	343-355	1X - Ø5.0 2X - Ø6.0 3X - Ø5.5 4X - Ø4.5 5.5X - Ø4.0	>0.6	MBE-1X-5.5X-0343-0355-v.3.4.3
1.1x-5.5x	515-532	1.1X - Ø5.0 2X - Ø7.0 3X - Ø6.5 4X - Ø5.5 5.5X - Ø4.5	>0.9	MBE-1X-5.5X-0515-0532-v.3.4.3
1.1x-5.5x	1030-1064	1.1X - Ø6.0 2X - Ø9.0 3X - Ø8.0 4X - Ø7.0 5.5X - Ø5.5	>2.2	MBE-1X-5.5X-1030-1064-v.3.4.3

* Max input beam diameter at $1/e^2$ intensity level ensuring diffraction limited performance.

Type SD Industrial Mirror Mounts



Standard specifications

Mechanical angular range*	± 3.5°
Resolution*	10 mrad/rev
Pointing stability	<2 µrad deviation after extensive temperature cycling on Type SD mount size

* Depends on Type SD mount size.

Description

Type SD industrial precisely adjustable mirror mount provides excellent performance for demanding applications. Design ensures stress free low distortion mounting for optics, excellent holding force and pointing stability. Type SD mount allows precise mirror adjustment in both X and Y directions. 100TPI micro screws provide accurate adjustment and easily accessible fully integrated locking mechanism ensuring excellent angle stability. Depending on the application, optics can be held either by specially designed ZeroDef flexure ring or by semi-permanent optical adhesives. Type SD mount is precisely machined from special alloys to provide optimum beam pointing stability over changing environmental conditions such as temperature and transportation shock as well as vibrations and humidity.

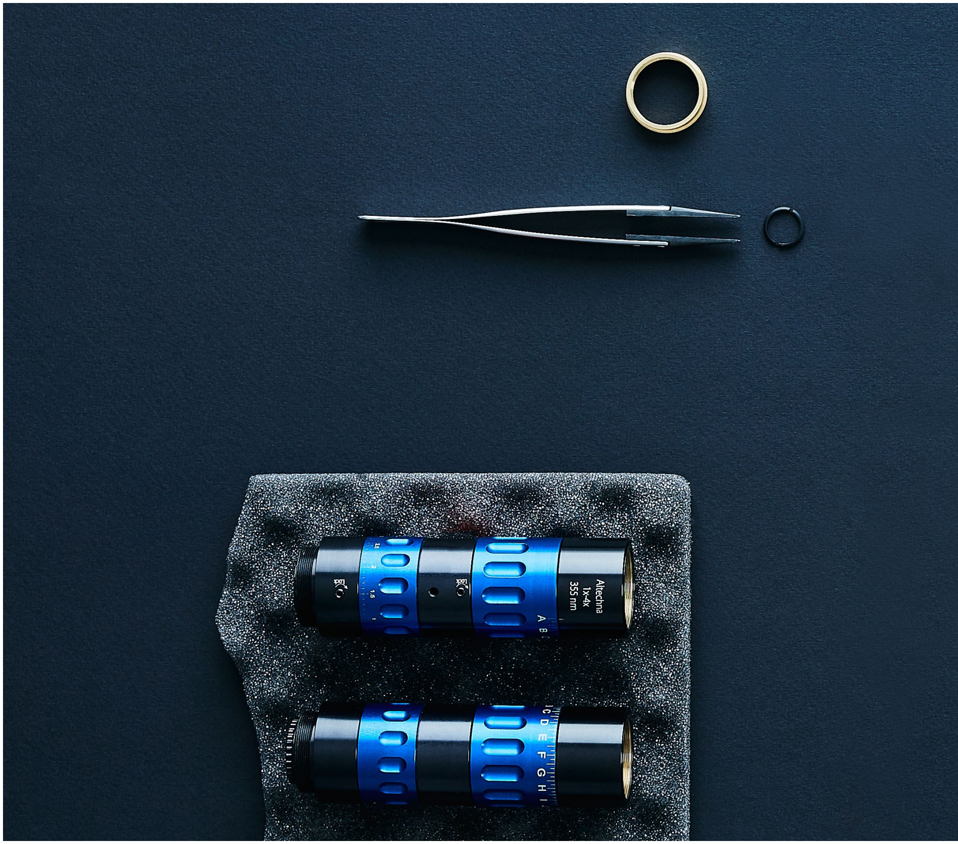
Features

- Vacuum compatible, no outgassing
- High temperature and vibrational stability
- Reliable and easy to use lock mechanism
- Fast & easy replacement of optics using ZeroDef flexure ring (RS)
- Stable and distortion free mounting of optics

Typical items**

Optics diameter, mm	Optics thickness, mm	Physical dimensions (H x W x L), mm	Product ID
12.7	3	25.4 x 25.4 x 20.0	SD-127-03-VC-RS-M
25.4	6	40.0 x 40.0 x 25.5	SD-254-06-VC-RS-M
30.0	6	45.0 x 45.0 x 25.4	SD-300-06-VC-RS-M
38.1	5	55.0 x 55.0 x 27.8	SD-381-05-VC-RS-M
50.8	8	69.0 x 69.0 x 29.9	SD-508-08-VC-RS-M

** Custom mount configurations are available on request.



Mokslininku st. 6A
08412 Vilnius
Lithuania

+370 5 272 5738
info@altechna.com

altechna.com

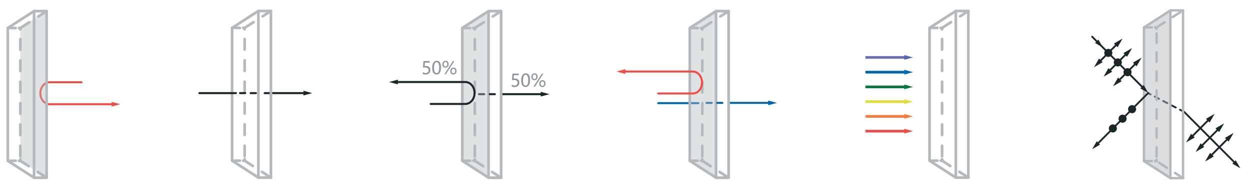
Magnetron Sputtering Coating Features

MS technology designed for industrial volumes

	MS	IBS	E-beam	IAD
Price	●●○○	●●●●	●○○○	●○○○
Performance	★★★★	★★★★	★★☆☆	★★★☆

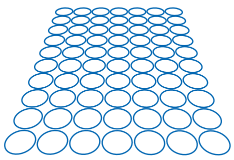
Coating types:

1. Highly reflective
2. Anti-reflective
3. Partially reflective
4. Wavelength separating
5. Broadband
6. Polarizing



Quantities per coating run:

- 518 pcs. of Ø 25.4 mm
- 126 pcs. of Ø 50.8 mm
- 42 pcs. of Ø 76.2 mm
- 14 pcs. of Ø 200 mm
- 5 pcs. of Ø 260 mm



Equipment:

- Evatec Radiance (Switzerland)

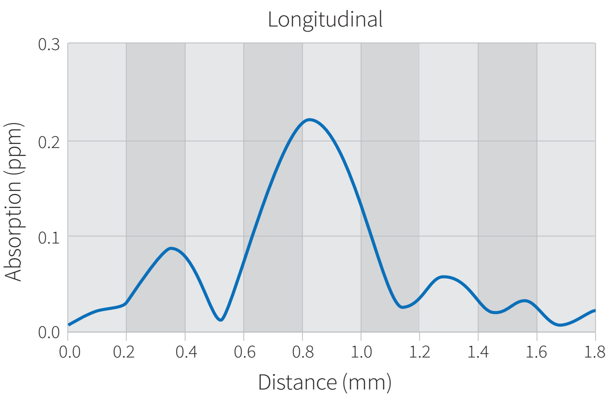
Spectral performance:

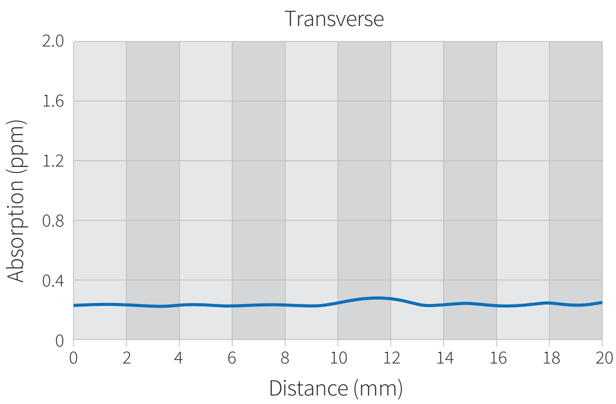
- 400-3000 nm range
- R max > 99.96%
- AR max <0.1%

Low absorption:

- AR coatings <1 ppm @1064 nm
- HR coatings <10 ppm @1064 nm

<0.3 ppm @ 1064 nm

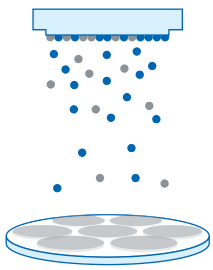




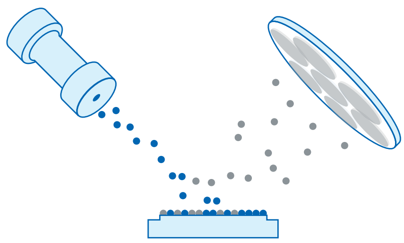
Surface absorption measurement graphs of AR coated IRFS substrate.

Available Coating Technologies

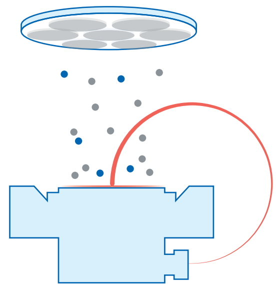
MS



IBS



E-BEAM + IAD



	Magnetron sputtering	Ion beam sputtering	Electron beam evaporation	Ion assisted deposition
Deposition rate	2-6 Å/sec	1-3 Å/sec	>5 Å/sec	1-5 Å/sec
One inch substrates per run	518 pcs.	53 pcs.	90 pcs.	90 pcs.
Thermal conductivity	High	High	Low	Medium
Temperature range during process	20-100 °C	20-100 °C	200-300 °C	20-200 °C
Density / Porosity	Near bulk	Near bulk	Porous	Dense
Adhesion / Durability	Excellent	Excellent	Low	Good
Sensitivity to humidity	No	No	Yes	Yes, small
Aging effects	No	No	Yes	Yes, small
Coating spectral accuracy	High	High	Low	Medium
Maximum HR @ 1064 reflectivity	>99.96%	>99.99%	99.5-99.8%	99.9%
Intrinsic stress	200-400 MPa	300-600 MPa	<100 MPa	~100 MPa

Altechna, UAB
Mokslininku st. 6A
08412 Vilnius, Lithuania
Tel. +370 5 272 5738
Fax +370 5 272 3704
info@altechna.com
www.altechna.com

2 μm Laser: From Research to Industrial Applications

By Laurynas Šatas, 2020

Over the past few decades, lasers have become an increasingly crucial tool for multiple applications. By selecting right tool and optimizing it's parameters professionals can cover wide range of different technological tasks with optimum efficiency. Lasers operating at the wavelength range of 2 μm is highly demanding due to its unique properties. Water absorption increases steadily from 1.2 to 2.9 μm, resulting in wavelengths of around 2 μm still belonging to the so-called "eye safe" region – with water making up around 70% of corneal tissue. Through falling within this region and still being at suitable atmospheric window, lasers operating at the wavelength of 2 μm enable an entire range of applications and opportunities for free-space communication, remote detection (for atmospheric absorbers: H_2O, CO_2, N_2O, etc.) and spectroscopic advances in environments that cannot be isolated from people.

While these lasers are considered eye safe, the same water absorption line located at these wavelengths makes such lasers some of the preferred tools for precision surgery. With direct or endoscopic medical applications, there are only two critical parameters that matter: coagulation and ablation depth. Small coagulation zones help doctors to contain bleeding and significantly improve procedural quality, whereas large ones can disturb the functionality of tissue. Precise control of ablation depth and affected zones is highly important in allowing professionals to ensure a high level of accuracy in precision surgery.

It has been shown that the actual wavelength is also important for the ablation of biological tissue. A comparison between two of the most popular laser systems – Ho:YAG and Tm:YLF – suggests that the sweet spot is located somewhere around 2090 nm. At the same average powers, Ho:YAG lasers show almost twice the ablation depth while maintaining smaller coagulation zones than Tm:YLF lasers. In addition ability of Ho:YAG lasers to work in different regimes (CW and Q-switched with electro-optical or acousto-optical modulators [4]) and tune wavelength from 2090 to 2123 nm leads to extraordinary process control.

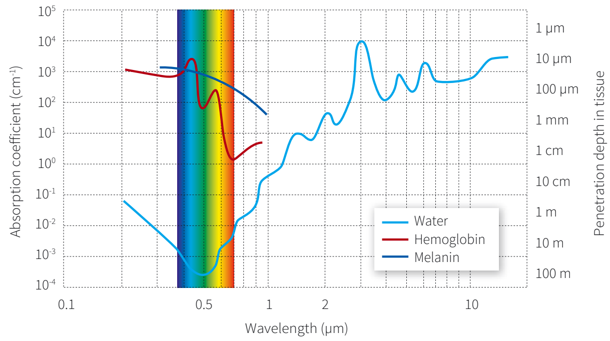


Figure 2. Absorption and penetration depth in water and other biological tissue constituents for different wavelengths [1].

High importance applications also include defense and security fields. IR guided missiles were responsible for 90% of damaged planes in conflict areas around the world over the past 20 years. Direct infrared counter measure (DIRCM) systems serve a crucial role in protecting planes from these heat-seeking projectiles. Therefore it is crucial to have a compact and reliable DIRCM system as it can save a plane and the lives of its crew. These systems come in two types: one operates in the first atmospheric window at wavelengths of around 2 micrometers, and a second is designed for the second atmospheric window of 3-5 μm. The latter is typically a high-complexity hybrid laser system containing a thulium-based diode-pumped fiber laser, Ho:YAG in a solid state and a zinc germanium phosphide (ZGP) optical parametric oscillator [3]. Challenges with DIRCM systems can be properly addressed only through multiple stages of optical pumping, which result a bulky and expensive system.

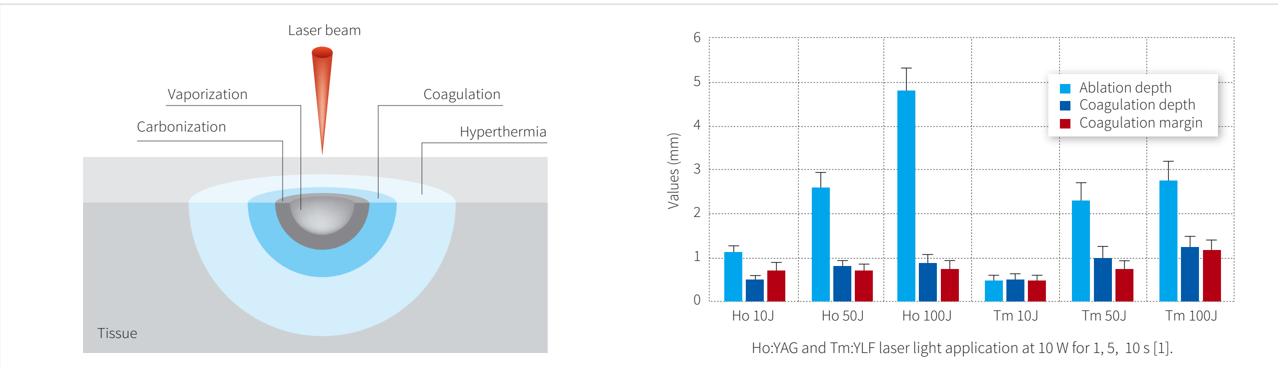


Figure 1. Single-spot experiments (fiber-tissue distance d = 5 mm) on porcine liver tissue using Ho:YAG and Tm:YLF laser in CW mode (P = 10 W, t = 1, 5, and 10 s). Mean and standard deviations of ablation depth, axial coagulation depth and width of the radial coagulation edge are shown [1].

Dielectric coatings

Interference coatings are constituents that make optical glass into a low-loss window or laser mirror. Depending on the technology used, coating density can range from highly porous to near-as-bulk. In typical NIR nanosecond applications, it is known that more porous coatings are capable of surviving higher energy densities due to having lower stresses. However, in the spectral region where water absorption is critically important, technologies that are highly functional at 1 µm range do not work at 2 µm as well.

A great rule of thumb when considering best optical coatings at 2 µm range is that the higher the coating density the better. Ion beam sputtering and magnetron sputtering technologies are perfectly suited for this through their ability to achieve the highest coating density and degree of precision. Such coatings are not affected by environmental humidity and are free of H_2O content within layers. While in some systems components can be sealed off and protected with inert gases, coatings based on sputtering technologies are the only viable option for the operation under atmospheric conditions.

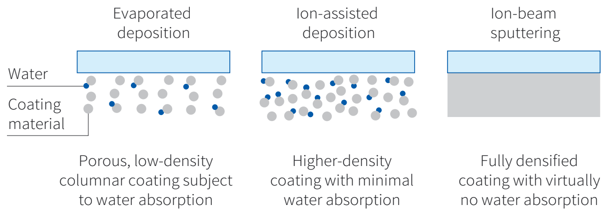


Figure 4. Evaporative deposition produces porous coatings that can absorb moisture, while IAD reduces this problem and IBS completely eliminates it [5].

Challenges

Depending on the application, there can be several different challenges that laser engineers need to address in the development of new-generation laser sources. Stability, beam quality and certain power levels are key to most remote-sensing or medical applications, while in the defense market it is size, weight and efficiency that are even more important and difficult to achieve. For a system to become smaller, lighter and more powerful, it means having a narrower spot size and higher fluencies that optical components must be able to withstand. The lifetime and stability of the weakest component will therefore define the longevity of the system itself, with the need to give special attention to the production of each individual component.

Continuous irradiation going through a volume of amorphous glass will run into all the impurities and potential absorbers typical for the actual wavelength. In the 2 µm region, the biggest foes are OH absorption bands, which cause local heating of glass that results in thermal lensing and distortions. This well-known issue is easily resolved with the right selection of infrared-grade fused silica (OH concentration <5 ppm) or calcium fluoride optics.

Altechna solution for 2 µm applications

The development of new-generation optical components capable of managing today's challenges is a complex process. It involves more than one discipline, ranging from material science to engineering. Altechna engineers have identified several technological bottlenecks of laser systems that work in the region around 2 µm and prepared a full industrial solution. High-quality optical components for laser resonators and delivery optics are now available in prototyping quantities, as well as for mass production.

Beam steering optics

- Any common infrared-grade fused silica (Corning 7979®, Infrasil®, etc.)
- Excellent accuracy for ROC and centering tolerances
- Dielectric coating sputtered with metal oxides
- LIDT: >30 J/cm² @ 2090 nm, 10 ns*

High LIDT Ho:YAG laser crystals

- Ho^{3+} concentration: 0.5 - 2%
- Surface quality: 10-5, S-D
- Surface flatness: <λ/10 @ 632.8 nm
- Parallelism error: <5 arcsec
- LIDT: >30 J/cm² @ 2090 nm, 10 ns*

High LIDT cavity mirrors

- Any common infrared grade fused silica (Corning 7979®, Infrasil®, etc.)
- EM optimization
- Low-loss design
- Dielectric coating sputtered with metal oxides
- LIDT: >30 J/cm² @ 2090 nm, 10 ns*

*NOTE: No damages were found while testing, therefore, LIDT value could not be evaluated. LIDT value should be higher than maximum fluence value used in the test. This fluence value is written in the specification table [6].

References

1. Frontiers in Guided Wave Optics and Optoelectronics, Book edited by: Bishnu Pal, ISBN 978-953-7619-82-4, p. 674, February 2010, INTECH.

2. Antipov, O., Zakharov, N., Fedorov, M., Shakhova, N., Prodanets, N., Snopova, L., Sharkov, V. & Sroka, R. (2011). Cutting effects induced by 2 µm laser radiation of cw Tm:YLF and cw and Q-switched Ho:YAG lasers on ex-vivo tissue. Medical Laser Application, 26, 67–75. doi: 10.1016/j.mla.2011.02.004.

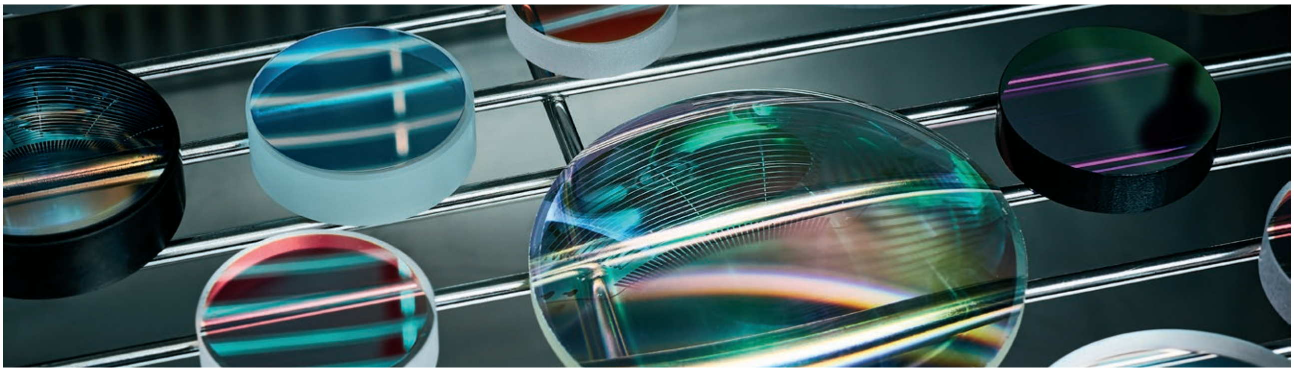
3. Hemming, A., Richards, J., Bennetts, S., Davidson, A., Carmody, N., Davies, P., Corena, L., Lancaster, D. (2010). A high power hybrid mid-IR laser source. Optics Communications, 283 (20), 4041–4045. doi: 10.1016/j.optcom.2010.05.078.

4. Wang, Y. P., Dai, T. Y., Wu, J., Ju, Y. L., & Yao, B. Q. (2018). A Q-switched Ho:YAG laser with double anti-misalignment corner cubes pumped by a diode-pumped Tm:YLF laser. Infrared Physics & Technology, 91, 8–11. doi: 10.1016/j.infrared.2018.03.020.

5. Trey Turner, Laser Focus World (2011), Thin-film coatings: Military laser technologies challenge optical-coating manufacturers, <https://www.laserfocusworld.com>.

6. Tested at Lidaris, JSC.

Altechna



Transmissive Optical Components for >100 kW CW Laser Systems

Fiber end caps, <1 ppm absorption AR coated optics

By Marius Gželka, 2019

High-power continuous-wave laser systems

Since the invention of the first laser in 1960, the constant development and expansion of laser technology has led to the production of the modern-day versions of high-power continuous-wave (CW) laser systems that are now being used in various industries (such as material processing, heavy industry, etc.). As they help to increase the growth of companies and open up new opportunities, they are becoming one of the key components of these sectors. In one of the most common applications - processing of materials (including cutting, drilling and welding) - laser systems bring many benefits compared with alternatives, such as flexibility (enabled by a wide choice of parameters), high speed, precision processes, automation feasibility and low maintenance requirements [1]. Nowadays, industrial laser systems are reaching continuous-wave powers at the hundreds of kilowatts level [2]. Manufacturers of different types of lasers (fiber, solid-state, CO_2, etc.) are involved in power-scaling competition, and while that is one of the goals that unites them, there are also some shared unwanted effects that they all face in developing such systems.

Optical components for high-power CW systems

Optical components are the most critical part of high-power CW laser systems which, in most cases, are a limiting factor for the output power. In solid state lasers, they are used in almost every stage (intra-cavity, beam delivery optics, etc.), while for fiber lasers they are mostly used for output and beam delivery purposes. One of the most important components of high-power fiber laser systems is end caps. End caps must withstand the highest power fluences (the purpose of the end cap is an initial reduction of the power density) while keeping the appropriate beam quality; thus, special attention needs to be paid to this optical component [3]. Since high-power CW laser systems enable extremely high power fluences, when the light passes through the optical component part of the energy is absorbed and converted into heat, which can have a number of detrimental side effects. One of these negative effects is the heating of the remaining parts of the system (holders, electronic schemes etc.) which poses a threat to the appropriate performance of the laser system. Another side effect is thermal lensing, it causes a distortion of the beam quality and the beam focusing, which could lead to a potential system failure (damage of further optical components) or introduce inaccuracies into the application [4]. The worst case scenario is laser-induced damage to the optical component [5]. Damaged components can no longer be used, which means that the maintenance and cost of the laser system increases with each low LIDT component. It also results in major disruptions to the further development of the system. Since thermal absorption is the dominant mechanism in a continuous-wave regime [5], absorption of the optical component must be reduced to a minimum level. These issues present a real challenge for the manufacturers of optical components, whose main task is to enable the further development of such laser systems.

Challenges of enabling higher powers

In order to enable the further power scaling of laser systems, constant attention must be paid to the development of top-notch optical components. The most important milestones in the manufacturing process of optical components have to be understood. Once they have been identified, the processes must be strictly controlled and display repeatability. There are several stages of the manufacturing process, and each of them can be limiting factor for the entire optical system.

Selection of appropriate materials

The first step in the optical component manufacturing process is the selection of an appropriate material. The most popular materials used for laser applications in the UV-NIR range are fused silica (FS) and borosilicate (BK7) glasses due to their optical and mechanical properties. Depending on the application, the appropriate inclusion class and homogeneity grade has to be chosen. When it comes to high CW powers, especially in the NIR range, everything that could cause absorption has to be considered. In this case, special materials of the highest quality have to be used. Such high purity materials (Corning 7979, Suprasil 300, etc.) have low metal impurities (<1 ppm) and a low-oxygen hydrogen (-OH) concentration (<1 ppm) that results in no absorption bands from the visible to the NIR spectral region (Figure 1). Due to a more complex production process, the price of such materials is generally higher, but since it is very important to eliminate all possible absorption sources, the right materials for high-power laser systems have to be selected.

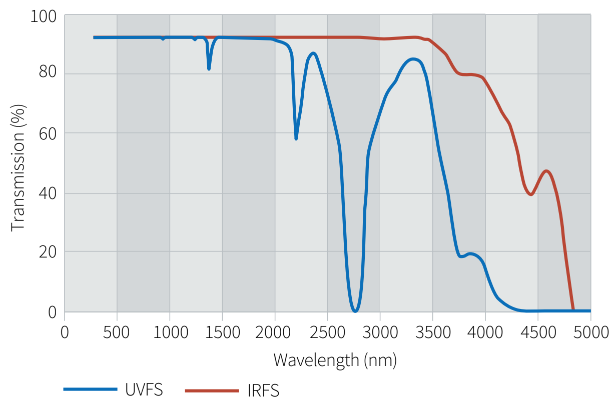


Figure 1. Transmission spectra of uncoated fused silica materials.

High quality material processing

Even when the right material has been selected, detrimental effects are not eliminated if improper material processing techniques are used. The primary optical component fabrication can be separated into a few main stages: shaping, grinding and polishing of the substrate. Each stage contributes to the quality of the finished substrate: it generates stress and strain on the optical surface and contaminates the substrate with polishing residuals [6]. These processing results increase the absorption and scattering, which results in lower LIDT values and a shorter lifetime of the optical component. In order to minimise these effects, it is very important to understand the correlation between the process and element quality, and to constantly make efforts to improve them. When an extremely high quality of the substrate is required, special polishing methods (such as MRF) are used after the conventional polishing. With such manufacturing stages, super polished substrates with <1Å surface roughness and minimal subsurface defects (SSD) are produced.

Special surface treatment methods for subsurface defects removal

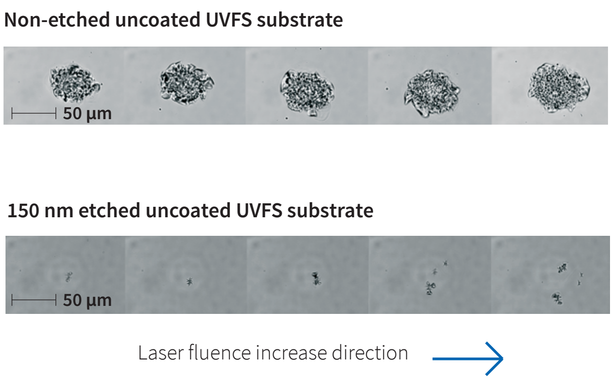


Figure 2. Damage morphology comparison of etched and non-etched substrates.

Even when high-end polishing methods are used, subsurface defects (the weakest links of an optical component) cannot be completely eliminated. For high power fluences, when an optical component of a perfect quality is required, finishing surface treatment processes should be considered. Contactless methods such as plasma etching help to reduce the SSD to the minimal level and increase the LIDT values of the optical components (Figure 2) [7]. However, a deep understanding and numerous experiments are required in order to select the optimal parameters (etched layer thickness, etching speed, etc.) for each case. The etching procedure is performed in the same coating machine vacuum chamber just before the coating process, which helps to prevent any contamination.

Selection of appropriate coating materials and coating technology

Coating materials have different properties and, depending on the customer's laser parameters, a perfect fit has to be selected. In some cases, even when all the parameters of the laser are locked and only the pulse duration changes (ns compared to fs), it is necessary to use different materials due to different damage mechanisms [5]. For high-power CW laser systems, absorption is the key factor of the optical component; thus, coating materials that have the lowest possible absorption and special methods for absorption reduction have to be used. Nonetheless, it is not only the coating materials that have an impact on the optical performance and LIDT values, but also the coating design (number, thickness of the layers, sublayers, etc.), which has to be customised according to each customer's needs. The coating technology also strongly influences the quality of the final product. Important properties, such as the optical performance, coating density, durability, sensitivity to humidity, aging effects, etc., depend on the selected technology. For the production of high quality optical components, Ion Beam Sputtering or Magnetron Sputtering (Figure 3) coating technologies are usually used.

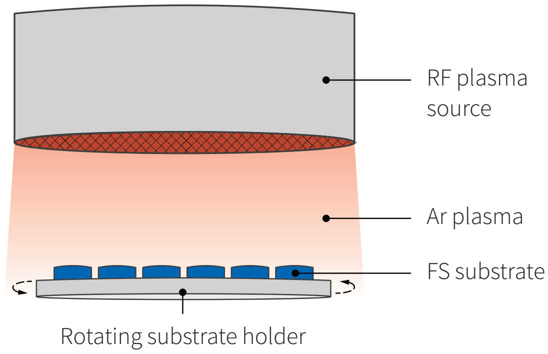


Figure 3. Altechna's Magnetron Sputtering coating technology.

Quantities per coating run:

- 1790 pcs. of Ø12.7 mm
- 518 pcs. of Ø25.4 mm
- 126 pcs. of Ø50.8 mm
- 42 pcs. of Ø76.2 mm

Altechna's solutions for the highest powers

After a thorough analysis of each production stage for optical components, and by working in collaboration with high-power laser manufacturers, Altechna has developed top-notch optical components for high-power CW laser manufacturers and integrators while ensuring perfect repeatability.

Low absorption and reflectance AR coatings

One of Altechna's latest achievements is extra low absorption (<1 ppm) (Figure 5) and reflectivity (<0.1%) (Figure 4) anti-reflective coatings for high-power CW laser applications. The coatings are made with Magnetron Sputtering coating technology, in addition to using special methods for minimising absorption.

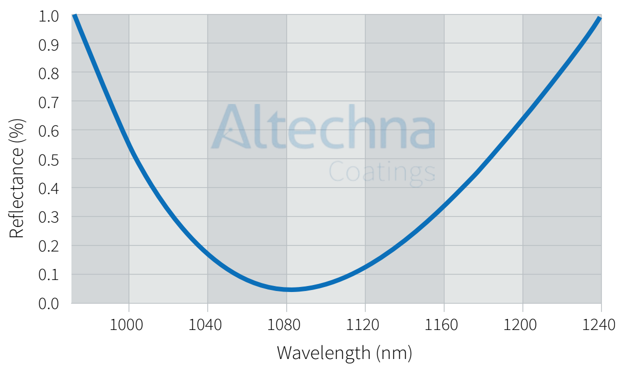


Figure 4. Reflectance spectrum of AR coated (1080 nm) IRFS substrate.

<0.3 ppm @ 1064 nm

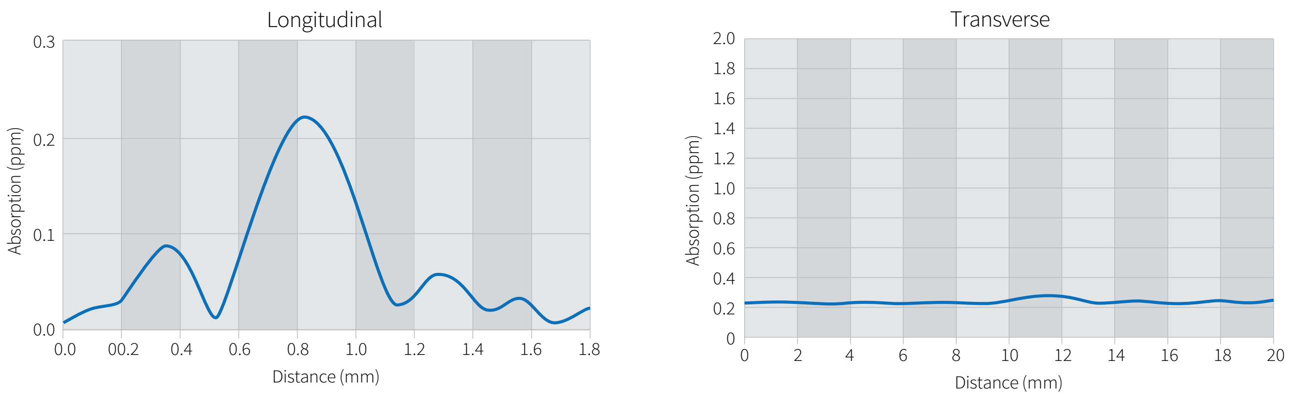


Figure 5. Surface absorption measurement graphs of AR coated IRFS substrate.

End caps for kW fiber lasers

Due to the small diameter of the fiber extremely high power densities can cause scorching and damage of the end-face. These detrimental effects can be avoided by using a fiber end cap, which helps to extend the range of applications to higher laser powers [3]. The beam divergence within the spliced end cap leads to significantly lower power densities at the glass/air interface; nevertheless, when high-power fiber lasers are used, the power densities are still sufficient to initiate strong heating and damage of the end cap which causes a lot of problems for high-power fiber laser manufacturers.

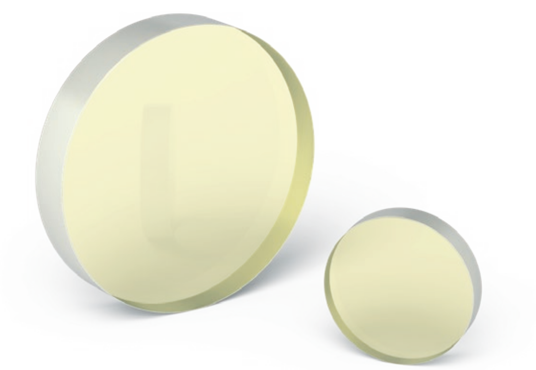
Altechna provides a solution by offering custom end caps with extremely low absorption (Figure 5), high LIDT values (Figure 6), tight mechanical tolerances and flawless optical performance, resulting in a perfect beam quality. Every specification is evaluated and confirmed in our metrology laboratory.

Main specifications:

- Material: Fused Silica (C7979, Suprasil 300 and similar)
- Surface flatness, PV: λ/10 @ 632.8 nm
- Surface quality: 10 – 5, S-D
- Parallelism: <10 arcsec
- Concentricity tolerance: <0.05 mm
- Perpendicularity tolerance: <0.05 mm
- Angle tolerance: <0.1°
- AR coatings: R <0.1%
- Absorption: <1 ppm

Protective windows for high-power lasers

Protective windows are found on the front part of every laser-cutting and welding system, and these are crucial for ensuring the reliable and uninterrupted operation of the laser systems. They are designed to be used as a safeguard for the more expensive optics and are placed as the last optics before the work piece. Our experience has led us to achieve spectacular results with high-power systems (Figure 6).



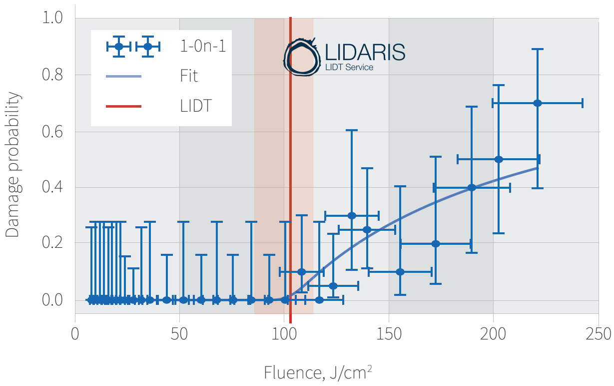
Main Specifications:

- Material: Fused Silica (C7980, C7979 and similar)
- Transmitted wavefront distortion, PV: λ/10 @ 632.8 nm
- Surface quality: 10 – 5, S-D
- Parallelism: <10 arcsec
- AR Coatings: R <0.1%
- Absorption: <1 ppm

LIDT measurements of Altechna's AR coated optical components

S (1)-on-1, 10 ns @ 1064 nm

102.6 (+11/-17) J/cm²



Spot diameter (1/e²) @ 1070 nm

87.7 kW/cm

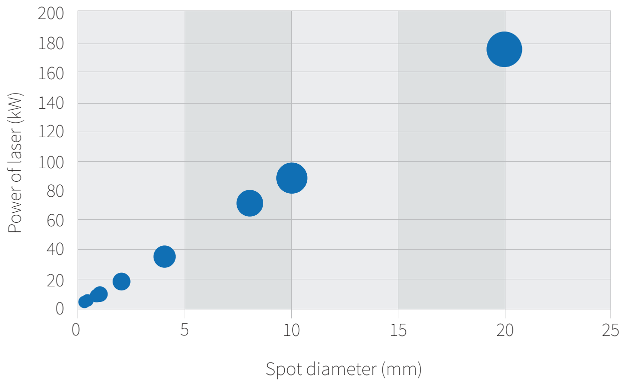


Figure 6. Pulsed and CW regime LIDT measurement graphs.

Custom transmissive optical components

We are able to offer solutions for any custom transmissive optical components (windows, lenses, prisms, etc.) used for high-power CW laser systems. Feel free to contact our professional team and we will provide you with our best support: sales@altechna.com

References

[1] Hull R., Jagadish C., Osgood, Jr. R.M., Parisi J., Wang Z., Warlimont H. / Laser Processing of Materials, Springer, Materials Science 139 (2010)

[2] Shcherbakov, E., Fomin, V., Abramov, A., Ferin, A., Mochalov, D., & Gapontsev, V. P. / Industrial Grade 100 kW Power CW Fiber Laser, Advanced Solid-State Lasers Congress (2013)

[3] Knigge A., Knothe C., Oechsner U., Federau G. / Fibers with end caps, Physics' Best, pp. 2-5 (2017)

[4] Bogan, C., Kwee, P., Hild, S., Huttner, S. H., & Willke, B. / Novel technique for thermal lens measurement in commonly used optical components, Optics Express, 23(12) (2015)

[5] Yu, J., Xiang, X., He, S., Yuan, X., Zheng, W., Lü, H., & Zu, X. / Laser-Induced Damage Initiation and Growth of Optical Materials, Advances in Condensed Matter Physics, 1–10 (2014)

[6] Pfiffer, M., Longuet, J.-L., Labrugère, C., Fargin, E., Bousquet, B., Dussauze, M., Néauport, J. / Characterization of the Polishing-Induced Contamination of Fused Silica Optics, Journal of the American Ceramic Society, 100(1), 96–107 (2016)

[7] Juškevičius, K., Buzelis, R., Abromavičius, G., Samuilovas, R., Abbas, S., Belosludtsev, Kičas, S. / Argon plasma etching of fused silica substrates for manufacturing high laser damage resistance optical interference coatings, Optical Materials Express, 7(10), 3598 (2017)

Optics for Advanced 50 J/cm² @1.5 μm Applications

By Laurynas Šatas, 2018

Growing interest in 1.5 μm

Over recent years there has been a growing interest for eye-safe laser sources emitting at ~1.5 μm [1]. Typically, such emission is provided by lasers based on erbium (Er^{3+}) ions and operating on the $^4I_{13/2} \rightarrow {}^4I_{15/2}$ transition. This radiation is strongly absorbed by the eye's cornea and lens and thus it cannot reach the sensitive retina which opens a new field for eye-safe applications. Erbium lasers are widely used in such applications as free-space optical communication, remote sensing (LIDAR technology), wind sensing and range-finding for civil and defence fields. While requirements for new generation industrial grade resonators operating at low pulse frequencies include a high pulse energy and peak power, they also depend on good beam quality and low divergence, as well as a compact and robust design, preferentially with passive cooling of a laser head.

Eye-safe laser

The design of such a laser is relatively simple. Materials for compact Er^{3+} lasers are phosphate glasses co-doped with Er^{3+} and Yb^{3+} ions [2]. Co-doping with Yb^{3+} ions is needed to provide the efficient pumping of the laser material at 960–980 nm according to the $^2F_{7/2} \rightarrow {}^2F_{5/2}$ transition of the Yb^{3+} ions. This spectral range corresponds to emission wavelengths of the cost-effective commercial high-power InGaAs laser diodes. The generation of a pulsed output from a compact Erbium laser is normally provided by the passive Q-switching. The well-recognized saturable absorber for an Er^{3+} laser is based on cobalt (Co^{2+}) ions located in tetrahedral sites of crystals, e.g. $Co^{2+}:MgAl_2O_4$ single crystal (Co^{2+}:spinel) . It provides high absorption cross-section for Co^{2+} ions and, consequently, low saturation fluence at the Er^{3+} laser wavelength (~0.5 J/cm²), fast recovery time (~350 ns), small non-saturable losses and high modulation depth, good thermal properties, and high radiation resistance. State of the art $Co^{2+}:MgAl_2O_4$ single crystals are grown by the Czochralski method. The growth is complicated by the high melting temperature of this compound (~2130 °C), but it is the only production route suitable for industrial applications with high repeatability in volumes of thousands finished optical components. As a potential replacement ceramic based solution is discussed around the world, but the problems of damage resistance, homogeneity and many more are not being solved so far. [3,4]

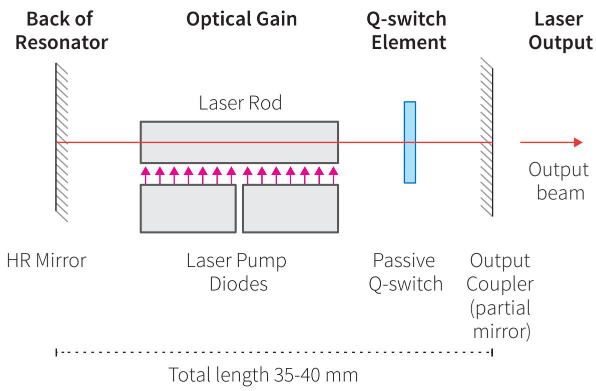


Figure 1. Typical 8 mJ resonator which could bring a challenge of 40-50 J/cm² to component

Challenges

From first sight, the 8 mJ single shoot (eye-safe limit for class 1 laser safety) doesn't sound like a big number in the century of high average power laser sources. However, optimization of compact and reliable cavity design is a challenging task for a laser engineer. For example, the resonator which emits 8 mJ with pulse duration at 15 ns and a beam diameter of 100 μm will put components to the challenge of handling more than 5.2 GW/cm^2 (>38 J/cm^2) intracavity, which is hardly achievable in the market. This problem can be solved by optimization of the following parameters:

1. Optimizing mode area of the laser
2. Consider a multi-mode solution instead of the single mode
3. Adjusting the output coupler and end mirror radius of curvatures
4. Adjusting initial transmission of Q switch and reflectivity of output coupler

However, all these adjustments are limited to a certain energy levels which can be withheld by the system's weakest optical component. This leads to reduction of other parameters such as beam quality, beam size, divergence, reliability, energy efficiency and overall price.

Laser damage threshold

Laser-induced damage (LID) is defined as any permanent laser radiation induced change in the characteristics of the surface/bulk of the specimen which can be observed by an inspection technique and at a sensitivity related to the intended operation of the product concerned. Laser-induced damage threshold (LIDT) is defined as the highest quantity of laser radiation incident upon the optical component for which the extrapolated probability of damage is zero. [5]

Components developed and manufactured in Altechna are typically qualified with determination of LIDT in by performing a standardized S-on-1 test procedure in LIDARIS (Lithuania). LIDT value is determined by fitting experimental damage probability data with a model derived for a Poisson damage process assuming degenerate defect ensemble. [6]

Altechna's solution for highest energies

Development of new generation optical components which are capable of managing today's challenges is a complex task. It involves more than one discipline starting from material science and ending with engineering. Altechna engineers identified several technological bottlenecks of high power Er^{3+} based solid state resonators and generated roadblocks to the solution. In particular, these systems require high-quality Co^{2+}:$MgAl_2O_4$ crystals capable of handling >50 J/cm^2 peak fluency coupled with superb optical and thermal properties. High-quality optical components based on recent technological breakthrough are going into production. Altechna expects that achieved power levels will allow our customers to reconsider resonator geometries and get new solutions for the applications such as remote sensing and range-finding for the civil and defence fields.

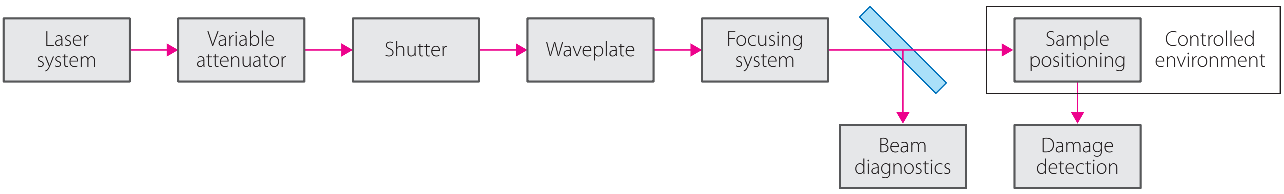
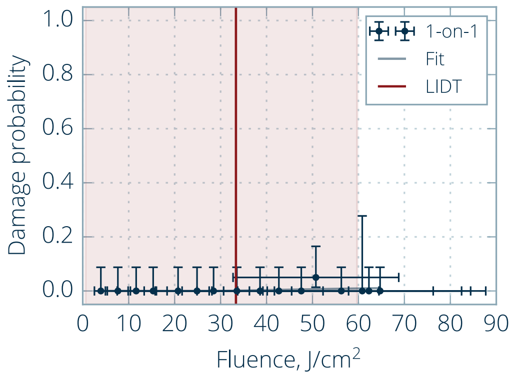


Figure 2. Typical LIDT test setup at 0° of incidence.

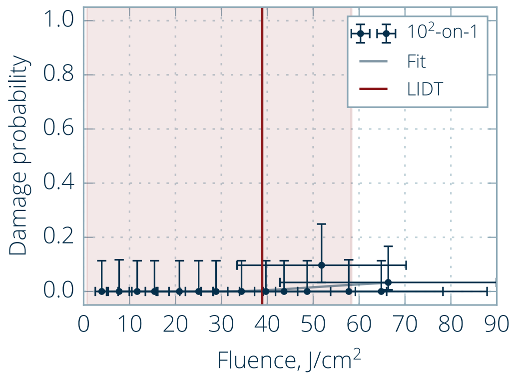
High LIDT Cavity Mirrors

1. Any common glass: N-BK7, UVFS
2. Superb accuracy for ROC and centering tolerances
3. Dielectric coating sputtered with minimum 3 metal oxides
4. EM field optimization
5. Low defect concentration
6. LIDT > 50 J/cm^2 @ 1540 nm, 20 ns, 100 Hz

*Measured LIDT 100-on-1 @ 1540 nm, 4.1 ns, 100 Hz, 0° – 39J/cm^2 (equivalent of > 86.1 J/cm^2 @ 20 ns)



(a) 1-on-1



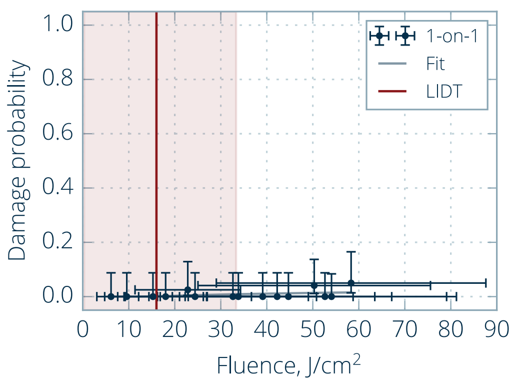
(c) 10^2-on-1

Figure 4. Damage probability plots. [7]

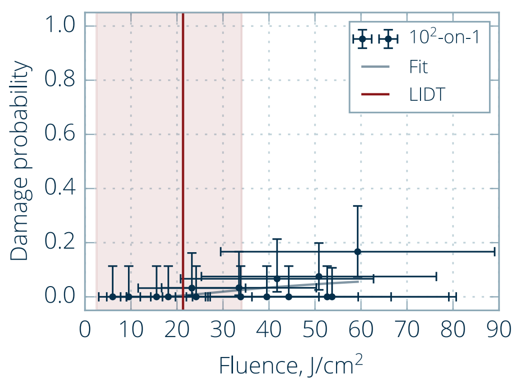
High LIDT output couplers

1. Any common glass: N-BK7, UVFS
2. Dielectric coating sputtered with a minimum of 3 different materials
3. EM field optimization
4. Low defect concentration
5. LIDT > 50 J/cm^2 @ 1540 nm, 20 ns, 100 Hz

*Measured LIDT 100-on-1 @ 1540 nm, 4.2 ns, 100 Hz, 0° – 21.3 J/cm^2 (equivalent of >46.48 J/cm^2 @ 20 ns)



(a) 1-on-1



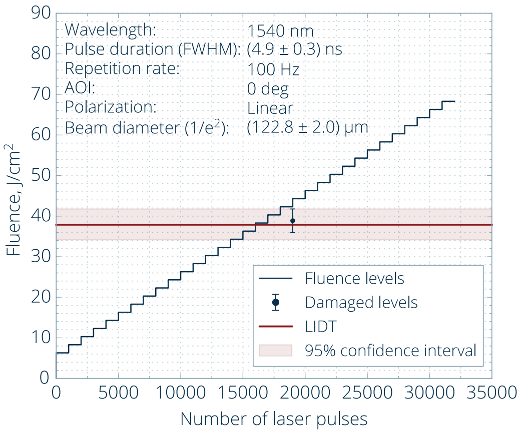
(c) 10^2-on-1

Figure 5. Damage probability plots. [7]

High LIDT coated Co:Spinel ($Co^{2+}:MgAl_2O_4$) crystals

1. Co^{2+} Concentrations: (0.05~0.35) wt%
2. Surface quality: 10-5 S-D
3. Surface flatness: <λ/10 @ 632.8 nm
4. Parallelism error: <5 arcsec
5. LIDT > 50 J/cm² @ 1540 nm, 20 ns, 100 Hz

*Measured LIDT R (1000)-on-1 @ 1540 nm, 4.9 ns, 100 Hz, 0° – 38.9 J/cm² (equivalent of >78.6 J/cm² @ 20 ns)



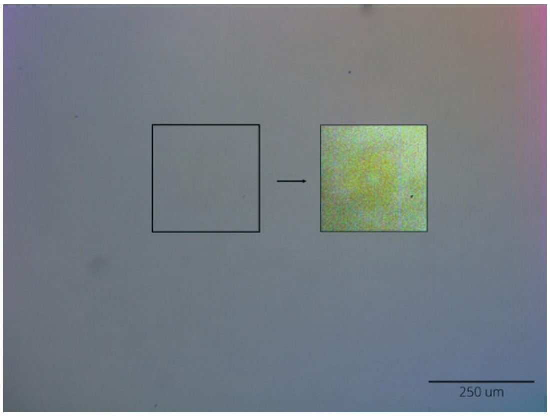


Figure 3. R-on-1 test results and typical damage morphology: fluence 38.9 J/cm², damage after 1000 pulse(s) in fluence level. High contrast image. [7]

References

[1] AANSI Standard Z136.1-2000, American National Standard for Safe Use of Lasers (2000)

[2] Karlsson G., Laurell F., Tellefsen J., Denker B., Galagan B., Osiko V. and Sverchkov S. „Development and characterization of Yb-Er laser glass for high average power laser diode pumping“ 2002 Appl. Phys. B 75 41–6

[3] Denisov I. A., Volk Yu. V., Malyarevich A. M., Yumashev K. V., Dymshits O. S., Zhilin A. A., Kang U. and Lee K-H. „Linear and nonlinear optical properties of cobalt-doped zinc aluminum „glass ceramics“ 2003 J. Appl. Phys. 93 3827–31

[4] Adrian Goldstein A., Loiko P., Burshtein Z., Skoptsov N., Glazunov I., Galun E., Kuleshov N., Yumashev K., „Development of Saturable Absorbers for Laser Passive Q-Switching near 1.5 lm Based on Transparent Ceramic $Co^{2}+:MgAl_2O_4$“ Journal of the American Ceramic Society • April 2016

[5] ISO 21254-1:2011: Lasers and laser-related equipment - Test methods for laser-induced damage threshold - Part 1: Definitions and general principles, International Organization for Standardization, Geneva, Switzerland (2011)

[6] ISO 21254-2:2011: Lasers and laser-related equipment - Test methods for laser-induced damage threshold - Part 2: Threshold determination, International Organization for Standardization, Geneva, Switzerland (2011)

[7] Tested at Lidaris