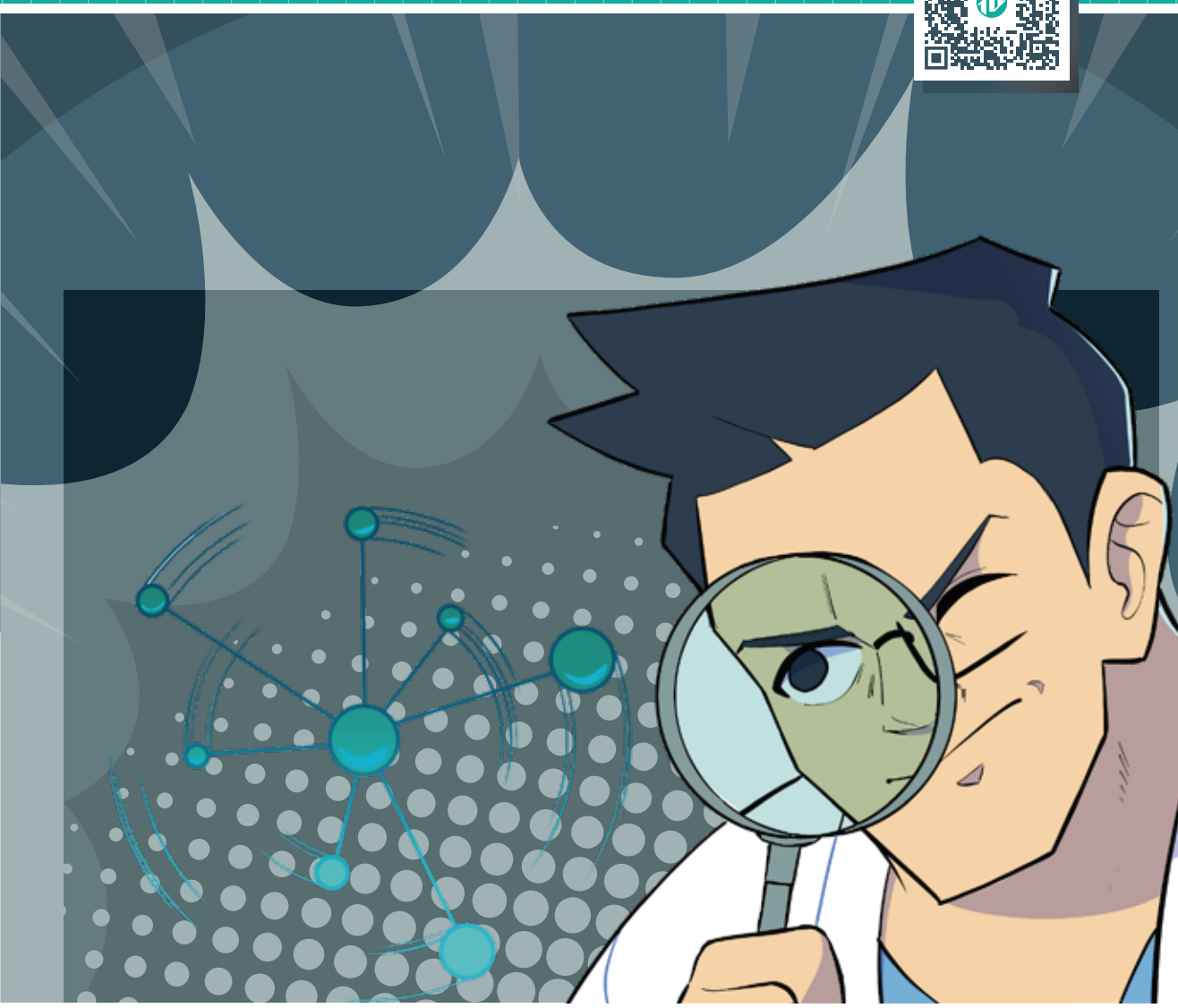
# OPTICS FOR LASER MICROMACHINING



OPTOMAN

YOUR SIDEKICK FOR
LASER OPTICS DEVELOPMENT

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Research & Developement

Optics for Inspection Measurement and Diagnostics Systems

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# ABOUT OPTOMAN

Born in 2017 in Vilnius, Lithuania, OPTOMAN is a coatings SuperHero, who designs, develops and manufactures advanced, high accuracy and repeatability thin film coatings by Ion-beam sputtering (IBS) technology. By digging deep into each application, OPTOMAN provides custom, application-optimized optics for academia and industry.

OPTOMAN as your sidekick is always willing and ready to help you with finding optimized solutions (ultra)fast and back you up in critical situations and finally get the job done as was promised.

## What makes OPTOMAN different?

Imagine you're the high-tech SuperHero, say Batman, and you need high-tech gadgets. You can try and find appropriate gadgets to buy, maybe even an Iron Man suit, but you're the Batman, you're unique, you have kick-ass martial arts skills and your gadgets need to support them. That's when Batman turns to Alfred, who develops gadgets, consults you and basically shares the same KPI - protect Gotham. OPTOMAN is Alfred.

HI, I AM OPTOMAN - YOUR SIDEKICK FOR LASER OPTICS DEVELOPMENT

### 80 % OF CUSTOMERS CONSIDER OPTOMAN A STRATEGIC PARTNER

(in OPTOMAN terms - a sidekick for laser optics development)*

## CORE COMPETENCE

- Ultrafast laser optics.
- High LIDT and enhanced lifetime.
- Durable and environmentally stable coatings.
- Extreme low-loss coatings.
- Agility, flexibility, and quick prototyping.

*Customer satisfaction survey results from 140 participants , 2023.

# DESIGN CAPABILITIES

## Extreme low-loss coatings:

- Super Mirrors HR (R>99.995%).
- Precision Thin-film Polarizers (Tp/Ts ratio > 10000:1).
- R<0.01% Anti-Reflective Coatings.
- Coating with an absorption loss of <1 ppm.

## Bread and butter

- Laser line and broadband mirrors (HR>99.99%).
- R<0.05% Anti-Reflective Coatings.
- Thin Film Polarizers (Tp/Ts extinction ratio > 1000:1).
- Pump, dichroic Mirrors (eg. HR>99.9% + HT>99%).
- Output couplers, plate beam splitters (eg. PR 50% +/-1%).
- Coatings can be applied on plane, spherical, cylindrical, aspherical, elliptical surfaces, prisms and other exotic configurations.
- Ultrafast (express) prototyping service available.

## Some of cool stuff we do:

- Knife-edge coated optics (edge chips <50 µm).
- 100% coated aperture components.
- Segmented/Masked coatings.
- Stress-compensated coatings (PV flatness <λ/20 @ 633 nm).
- Coatings on multi-surface prisms.
- Coatings on micro lens assemblies.
- Zero phase shift mirrors.
- Coatings on metal substrates.
- Optical assemblies.
- Coatings on fast axis collimators (FAC).
- Coatings on fibers and end caps.

- Custom shape, curvature and size.
- High reflection, anti-reflection, polarizing and other type of coatings available.
- **Spectral range 193 nm - 5000 nm.**
- **Size range from 3 mm up to 360 mm (500 mm is under development).**
- Optimization for 2, 3, 4 or more wavelengths.
- Various angles of incidence.

# METROLOGY CAPABILITIES

OPTOMAN metrology capabilities are based on partners oriented investments. Current metrology capabilties are below, but soon they will be supplemented.

- **LIDT & lifetime** - CW, ns, ps, fs
- **GD, GDD, TOD** - 500 nm – 1400 nm
- **Surface form errors** - Down to λ/20
- **Environmental testing** - To MIL-C-484197
- **Cosmetic surface quality** - To MIL & ISO
- **CRD** - 532 nm, 1064 nm
- **Absorption** - 355 nm, 532 nm, 1064 nm
- **Roughness/scattering** - 355 nm, 532 nm, 1064 nm
- **Spectral measurements** - Tsp, Rsp @ 200 nm – 5000 nm

# LIDT CAPABILITIES

High laser-induced damage threshold (LIDT) is a buzzword when talking about laser optics. Laser damage is a complex phenomenon and, while the result is the same – the optical component is ruined and not suitable for further use, there are different laser damage types and mechanisms. OPTOMAN takes innovation very seriously and makes sure that optical components are able to resist the ongoing increase of laser power and decrease in pulse duration, thus high LIDT is OPTOMAN's bread and butter.

Dr. Damage – the antagonist of the world of OPTOMAN can be beaten by measuring LIDT of laser optics. And OPTOMAN does just that.

**Reading the values:**
> Fluence @ Wavelength, pulse duration, repetition rate, beam diameter

## Femtosecond pulse

**High reflectance coatings:**
> 1.183 J/cm² @ 1030 nm, 507 fs, 1 kHz, 136.5 µm
> 0.286 J/cm² @ 343 nm, 180 fs, 10 kHz, 30 µm
> 0.267 J/cm² @ 258 nm, 180 fs, 10 kHz , 30 µm

**Anti-reflective coatings:**
> 0.052 J/cm² @ 515 nm, 191.4 fs, 300 kHz, 58.7 µm

**Polarizing coatings:**
> 0.77 J/cm² @ 1030 nm, 500 fs, 10 kHz, 175 µm

## Nanosecond pulse

**High reflectance coatings:**
> 168 J/cm² @ 1064 nm, 9.8 ns, 100 Hz, 223 µm
> 29.5 J/cm² @ 532 nm, 6 ns, 100 Hz, 137.6 µm

**Anti-reflective coatings:**
> 44 J/cm² @ 1064 nm, 10 ns, 100 Hz, 225 µm
> 10 J/cm² @ 532 nm, 10 ns, 10 Hz, 421 µm

**Polarizing coatings:**
> 49.4 J/cm² @ 1064 nm, 10 ns, 100 Hz, 206 µm

## Continuous-wave

**High reflectance coatings:**
> 426 kW/cm @ 1070 nm, 30 s, 137.6 µm*

**Anti-reflective coatings:**
> 426 kW/cm @ 1070 nm, 30 s, 137.6 µm*

* 426 kW was the power limit of the laser.

## Picosecond pulse

**High reflectance coatings:**
> 2.58 J/cm² @ 1064 nm, 370 ps, 20 Hz, 2.4 mm
> 1.64 J/cm² @ 532 nm, 350 ps, 20 Hz, 2.1 mm
> 8.313 J/cm² @ 1030 nm, 10 ps, 1 kHz, 154 µm

**Anti-reflective coatings:**
> 5.5 J/cm² @ 1064 nm, 370 ps, 20 Hz, 2.3 mm
> 2.1 J/cm² @ 532 nm, 350 ps, 20 Hz, 2.1 mm
> 0.39 J/cm² @ 343 nm, 1 ps, 1 kHz, 1 mm
> 0.353 J/cm² @ 800 nm, 1 ps, 1 kHz, 163 µm

**Polarizing coatings:**
> 2.7 J/cm² @ 1030 nm, 10 ps, 10 kHz, 115 µm

DISCLAIMER: Values are the result of LIDT test procedure according to ISO standards or based on the measurements done at customer sites. While the values are trustworthy, it doesn't mean that they can be transferred to final product specifications as the safety factor should be considered.

## BEATING DR. DAMAGE

# OPTOMAN AGAINST μ-ENEMIES FROM MICROMACHINING DIMENSION

As OPTOMAN is playing a protagonist role for laser system developers, the beam delivery setup in machines designed for micro drilling, micro structuring or micro shaping, motivated OPTOMAN to optimize Ion Beam Sputtering coatings for micromachining applications.

## KEY PROBLEMS

OPTOMAN has fought many battles. From the experience gathered throughout these years he highlighted main problems micromachiners face.

Short duty cycle and lifetime of machines caused by coating absorption and laser damage.

Beam profile deformation.

Polarization sensitivity requires beam delivery components to be optimized for s and p at the same time.

Multiple wavelengths coverage in the system.

## What can OPTOMAN do for μ-market?

**Lower cost of ownership due to enhanced lifetime**

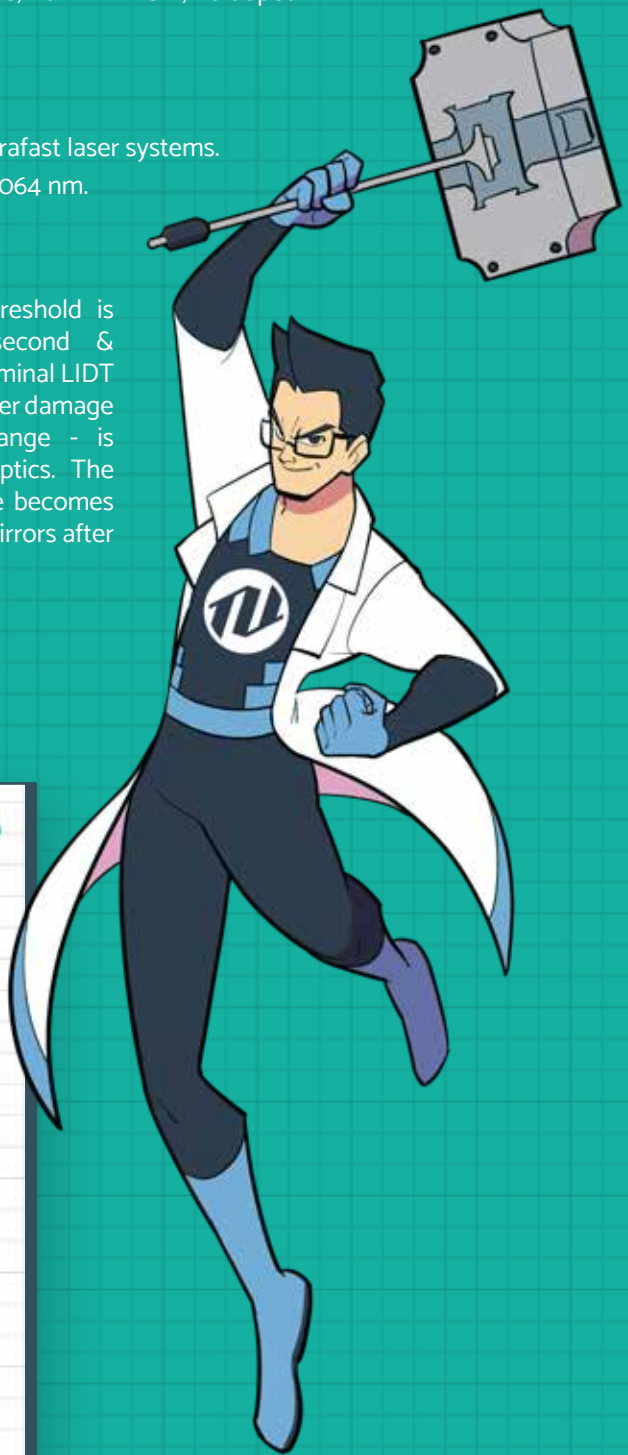
OPTOMAN's concentration on high LIDT and enhanced lifetime IBS coatings allows machine manufacturers to forget about headaches when components have to be replaced after a short period of time.

# MIRRORS FOR BIG & SCARY FS, PS LASERS

High laser power levels call for high-power measures. OPTOMAN is here to save the day with high reflectivity IBS mirror coatings designed for big & scary ultrafast Yb:YAG, Yb:KYW/KGW, Yb doped fiber lasers.

- Low GDD performance.
- Optimized for high average power ultrafast laser systems.
- Absorption within coating < 1 ppm @ 1064 nm.
- Zero-phase shift behavior.

While high laser-induced damage threshold is a buzzword when talking femtosecond & picosecond optics, it is not (only) the nominal LIDT value that matters. The separation of laser damage modes - catastrophic and color-change - is evident when measuring standard optics. The fatigue effect of color-change damage becomes even more significant for high-power mirrors after prolonged radiation (>$10^3$ pulses).

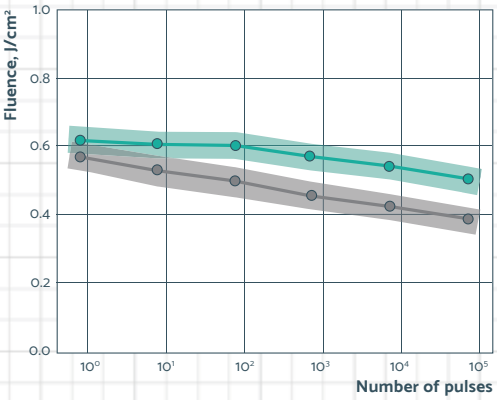


OPTOMAN has a number of 1/2", 1" and 2" spherical mirror substrates with focal lengths ranging from -10000 to -25 mm always available in stock to be coated on. It allows reducing the end product cost by at least 400%.

Scan to find out more

Color-change effect is an arch-enemy and a LIDT-limiting factor for ultrafast applications, and has to be eliminated in order to increase the lifetime of optics

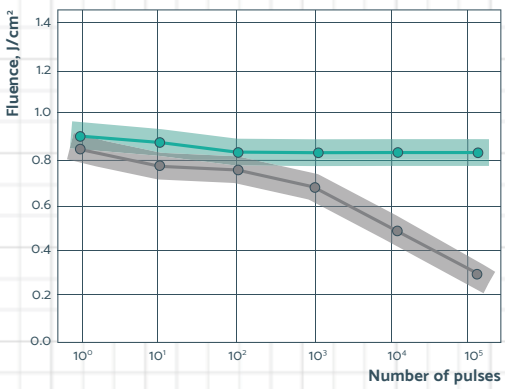
**Market-Standard Mirrors**




- Catastrophic
- 95% confidence interval
- Color change
- 95% confidence interval

Wavelength: 1030 nm
Pulseduration (FWHM): 491.1 fs
Repetition rate: 10 kHz
AOI: 45°
Polarization: Linear P
Beam diameter (1/e²): (177.4 ± 3.6) µm

**Market-Standard High Power Mirrors**



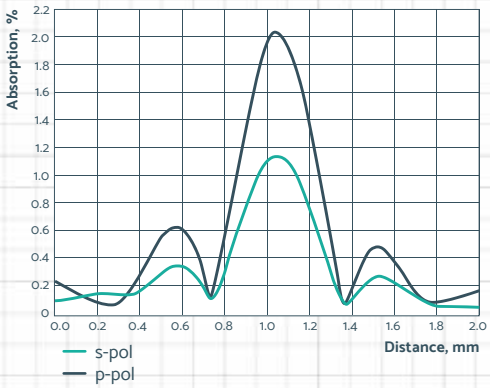

- Catastrophic
- 95% confidence interval
- Color change
- 95% confidence interval

Wavelength: 1030 nm
Pulseduration (FWHM): 491.1 fs
Repetition rate: 10 kHz
AOI: 45°
Polarization: Linear P
Beam diameter (1/e²): (177.4 ± 3.6) µm

It is well known that absorption is the main cause of laser damage. Strategically working towards color-change elimination, OPTOMAN did a number of R&D runs, aiming to optimize coating design, coating parameters as well as pre- and post- coating processes. Eventually, OPTOMAN was able to reduce coating absorption down to ~1 ppm for the s-polarization component and ~2 ppm for the p-polarization component:

**Absorption @ 1064 nm ~1 ppm for s-pol component and ~2 ppm for p-pol component.**

Measured by PCI technology.




Longitudinal photothermal absorption measurement of HR mirror.

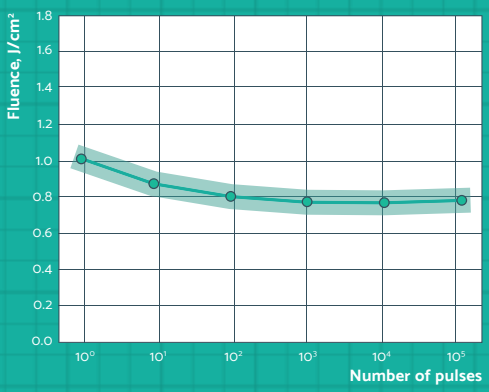
This achievement has paved the way to develop **a product specifically optimized for ultrafast laser applications – SuperHero League Mirrors featuring no color-change damage**. The LIDT of these mirrors is defined only by the catastrophic-damage values which have also been boosted and are higher than market-standard high-power mirrors.

# SUPERHERO LEAGUE MIRRORS (ULLM5SHL)

- Very high LIDT
- No color-change damage
- Fully characterized

Get it at OPTOSHOP

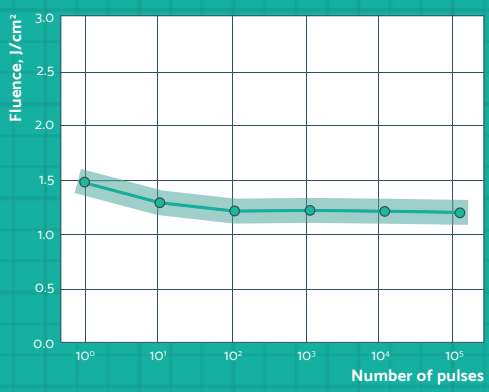
**High confidence level >0.7 J/cm²**




Catastrophic
95% confidence interval

Wavelength: 1030 nm
Pulseduration (FWHM): 497.7 fs
Repetition rate: 10 kHz
AOI: 45°
Polarization: P
Beam diameter (1/e²): (176.8 ± 4.8) µm

**High confidence level >1 J/cm²**




Catastrophic
95% confidence interval

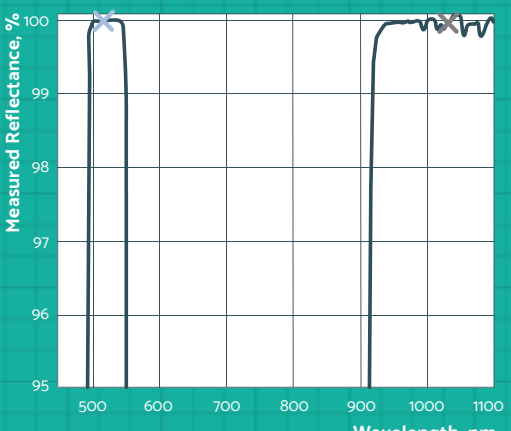
Wavelength: 1030 nm
Pulseduration (FWHM): 491.1 fs
Repetition rate: 10 kHz
AOI: 45°
Polarization: Linear S
Beam diameter (1/e²): (177.4 ± 3.6) µm

# 1030NM AND 515NM MIRRORS

Get it at OPTOSHOP

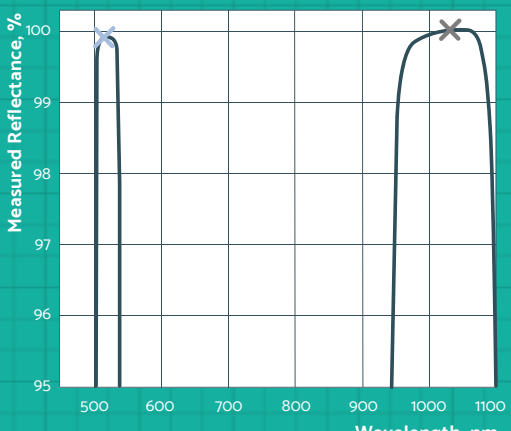
**HRsp>99.9% @ 1030 nm & HRsp>99.9% @ 515 nm, AOI=45°**

**S-pol**




99.99% @ 515 nm
99.97% @ 1030 nm

**P-pol**

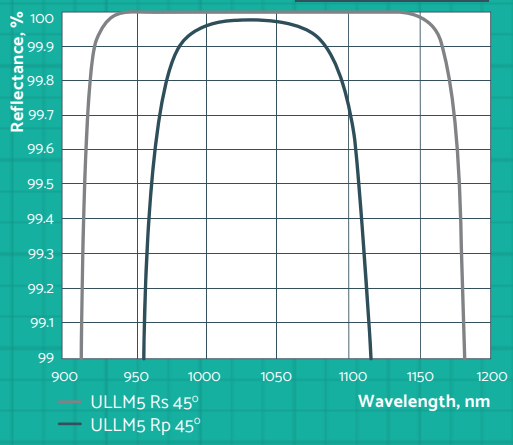



99.90% @ 515 nm
99.99% @ 1030 nm

## Single wavelength design examples

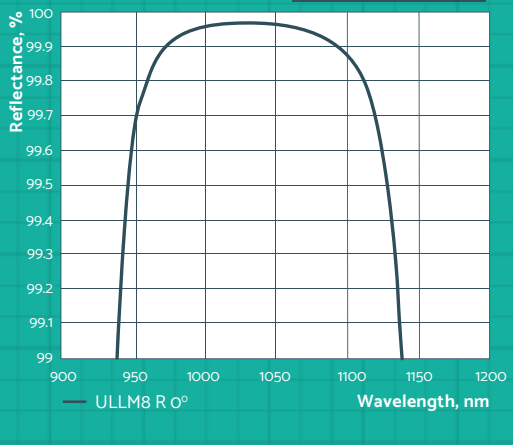
**HRs>99.95% & HRp>99.9% @ 1010 - 1050 nm, AOI=45°**

Get it at OPTOSHOP



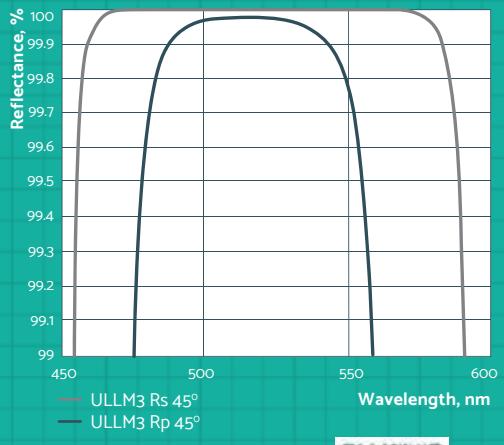

**HR >99.9 @ 1010-1050 nm, AOI=0°**

Get it at OPTOSHOP



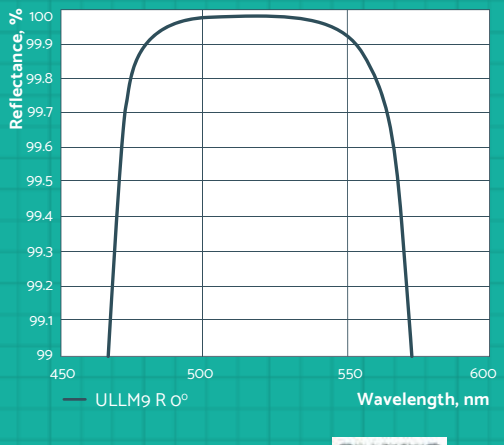

**HRs>99.95% & HRp>99.9% @ 505 - 530 nm, AOI=45°**

Get it at OPTOSHOP



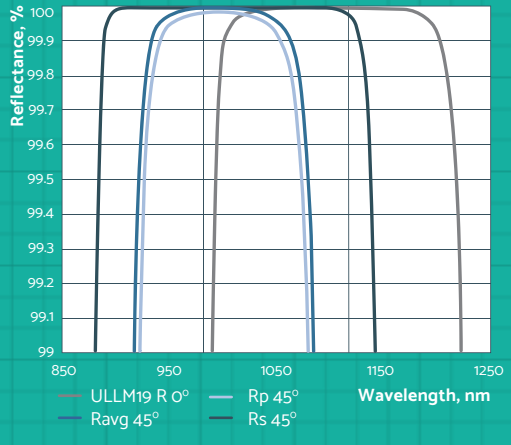

**HR >99.9 @ 505 - 530 nm, AOI=0°**

Get it at OPTOSHOP



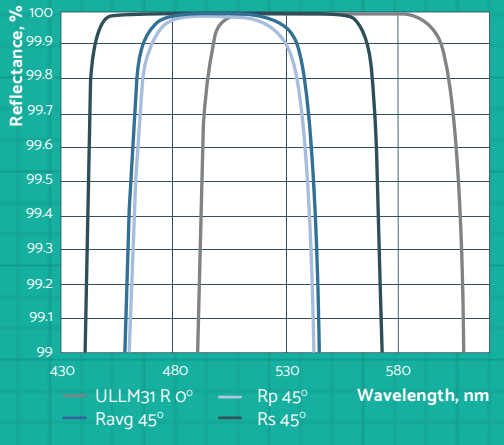

**HRa>99.9% @ 1030 nm, AOI=0-45°**

Get it at OPTOSHOP




**HRa>99.9% @ 515 nm, AOI=0-45°**

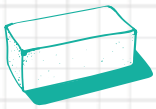
Get it at OPTOSHOP



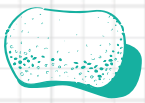
# ANTI-REFLECTION COATED OPTICS

Hundreds of companies Worldwide manufacture Anti-Reflection (AR) coated optics. What is so special about AR coated components from OPTOMAN?

**IBS AR coatings are extremely durable and environmentally stable due to the density of layers. Incredible resistance makes them perfect for on-field applications.**

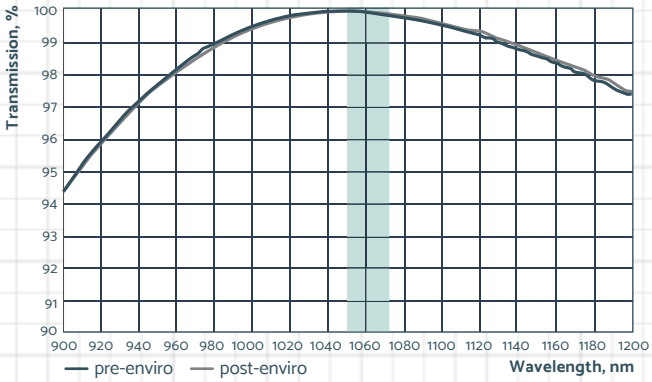


**IBS**
Near Bulk Density

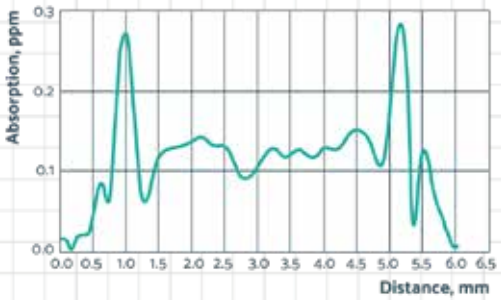


**E-beam**
Porous Structure

**AR@1064 nm coated sample performance before and after environment treatment cycles.**




**Low loss configuration allows transmittance higher than 99.98% of AR/AR coated components and absorption lower than 0.3 ppm @ 1064 nm, for example.**




Absorption measurement@ 1064 nm. Low absorption is responsible for thermal shift-free performance and negligible fatigue of coated surfaces.

Typical commercial AR coatings feature residual reflectance below 0.25% per surface. 0.1% is becoming quite a common value as well. In any case, imagine having a laser beam with 1 kW power passing through such a component. Transmittance loss is ~2 W – 5 W and this light goes somewhere back to the laser system...

With the low loss coating technology, OPTOMAN can reduce this number down to 0.2 W, because residual reflectance per coated surface can go below 0.01%.

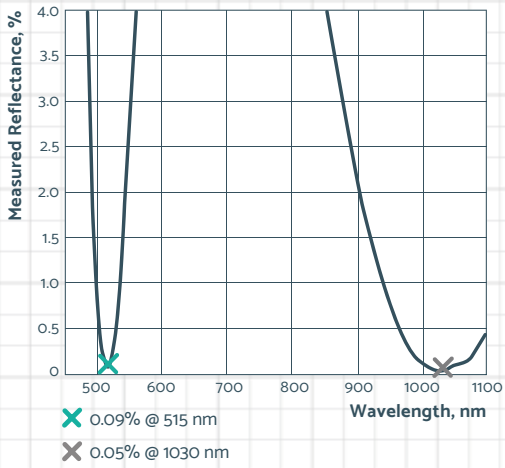
**Damage threshold > 40 J/cm² @ 1064 nm, 10 ns, $10^3$-on-1.**

## TYPES OF AVAILABLE AR COATINGS

| Low loss (R<0.01%) | Laser Line | Double-line | Triple-line | Multi-line | Broad-band | Wide acceptance angle |
|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |

## Design examples

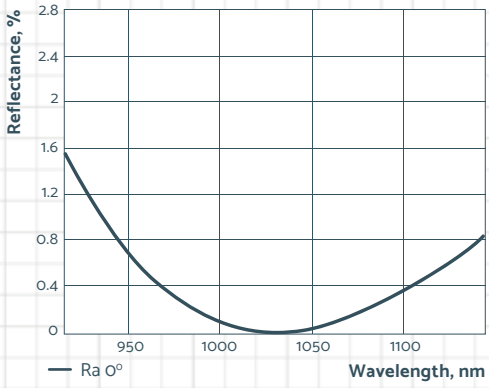
**S1&S2: AR<0.1% @ 1030 nm + AR<0.1% @ 515 nm, AOI=0°**



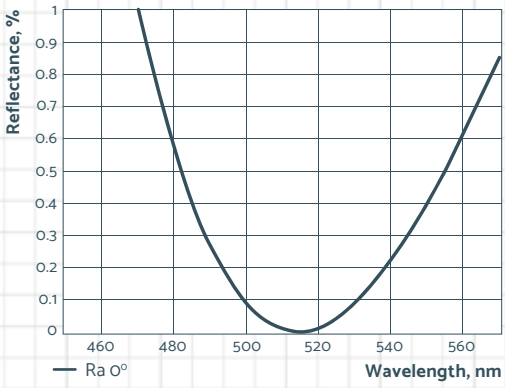

OPTOMAN has a number of 1 inch plano-concave lenses with focal lengths ranging from -1000 to -50 mm and plano-convex lenses with focal lengths between +50 and +2000 mm always available in stock to be coated on. It allows reducing the end product cost by at least 250%.

Scan to find out more

**AR<0.1% @ 1030 nm, AOI=0°**




**AR<0.1% @ 515 nm, AOI=0°**




OPTOMAN is flexible to manufacture coatings on many shapes and sizes.

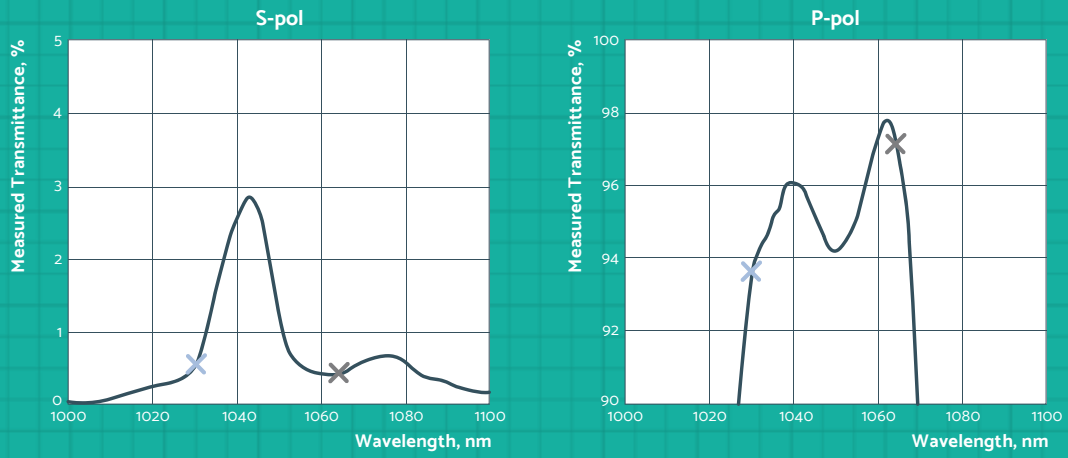
OPTOMAN has a partner if your system requires beam expander with IBS coated optics!

# THIN FILM POLARIZERS

**Thin film polarizers, which feature unique single wavelength or even multiwavelength separation on plate substrates have significantly lower absorption compared to cubes.**

## Multiwavelength design examples

**S1: Rs>99.2% & Tp>94% @ 1030 nm & Rs>99.0% & Tp>95% @ 1064 nm;**
**S2: ARsp<0.65% @1030 nm & 1064 nm**



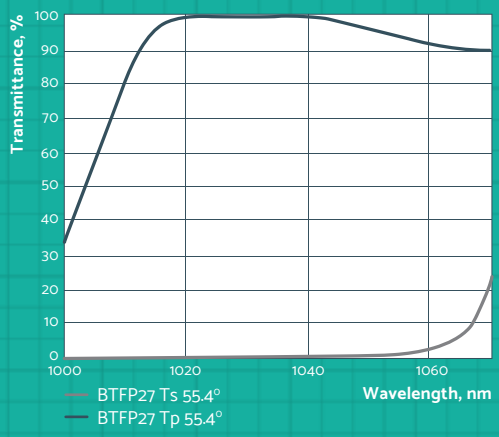

0.56% @ 1030 nm
0.42% @ 1064 nm

93.63% @ 1030 nm
97.16% @ 1064 nm

## Single wavelength design examples

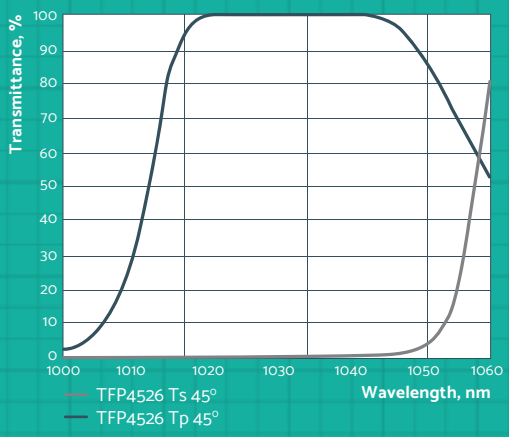
Get it at OPTOSHOP

**Rs>99.9% & Tp>98% @ 1030 nm, AOI =55.4°**
**(BTFP27)**




Get it at OPTOSHOP

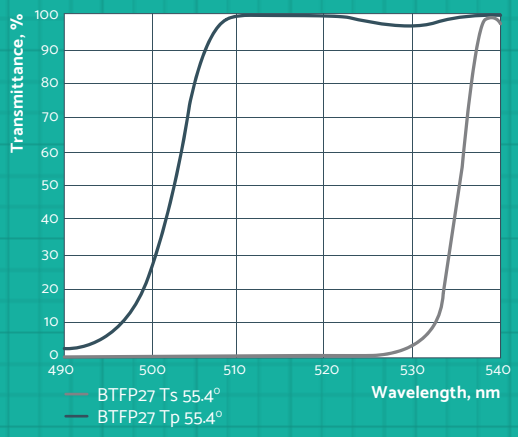
**Rs>99.9% & Tp>98% @ 1030 nm, AOI =45°**
**(TFP4526)**




Calculated TS and Tp values for BTFP27 and TFP4526 polarizers.

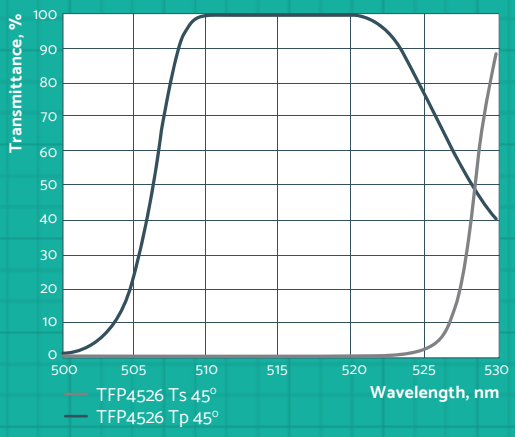
Get it at OPTOSHOP

**Rs>99.9% & Tp>98% @ 515 nm, AOI =55.4°**
**(BTFP28)**




Get it at OPTOSHOP

**Rs>99.9% & Tp>98% @ 515 nm, AOI =45°**
**(TFP4527)**




Calculated TS and Tp values for BTFP28 and TFP4527 polarizers.

# SUPERHERO POWER THIN FILM POLARIZERS (TFP)

**for high energy Q-switched lasers**

When it comes to a need for polarizing high pulse energy laser light, thin film polarizer is the only valid choice.

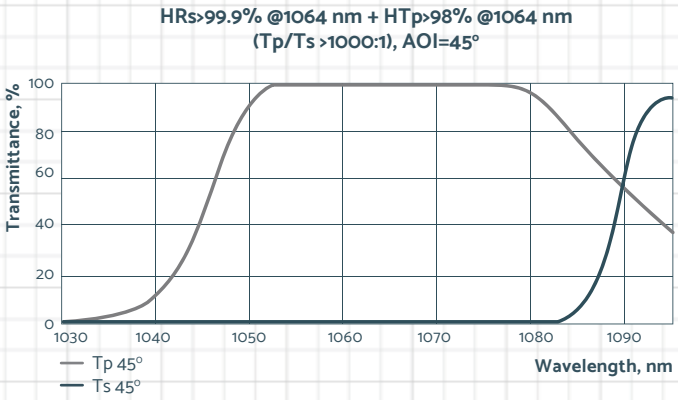
Fortunately, OPTOMAN has applied his **superpowers to develop superhero power thin film polarizers** for nanosecond regime.

Various angles of incidence 45°, 56°, 72°...

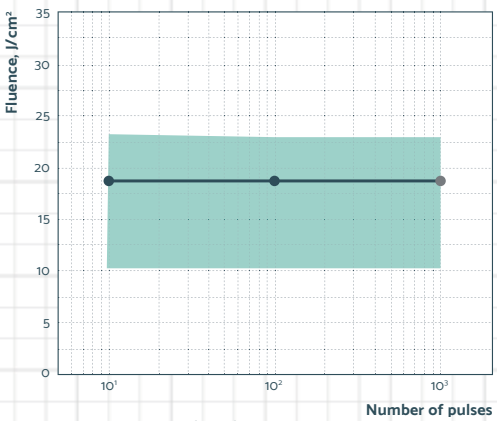
Single wavelength, dual-wavelength and broadband polarizers

| | | Measured LIDT values of SUPERHERO POWER POLARIZERS | |
|---|---|---|---|
| **Conditions** | **Market standard LIDT values for high power polarizers** | **Linear S polarization** | **Linear P polarization** |
| 1064 nm, 10 ns, 100 Hz, AOI 56°; beam 225 µm; $10^3$-on-1 | 5 - 10 J/cm² | **18.7 J/cm²** | **15.23 J/cm²** |

## Design examples



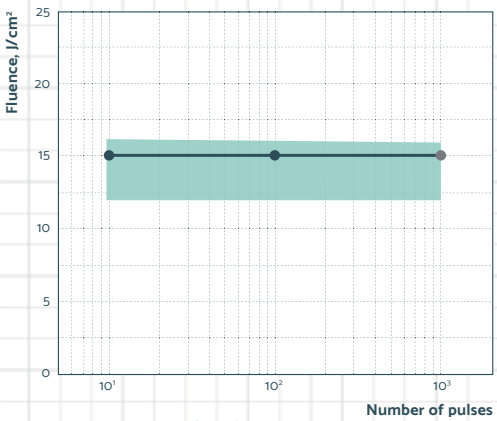
LIDT: >18.7 J/cm² @ 1064 nm, 10 ns, s-pol




Offline detection
Online detection
95% confidence interval

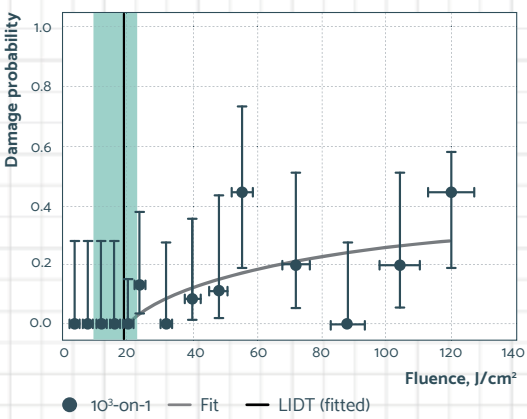
Wavelength: 1064 nm
Pulse duration (FWHM): (10.0 ± 0.3) ns
Repetition rate: 100 Hz
AOI: 56°
Polarization: Linear S
Beam diameter (1/e²): (225.8 ± 3.1) µm

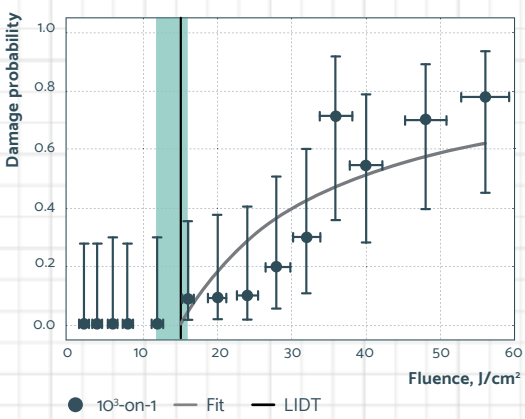
LIDT: >15.23 J/cm² @ 1064 nm, 10 ns, p-pol




Offline detection
Online detection
95% confidence interval

Wavelength: 1064 nm
Pulse duration (FWHM): (10.0 ± 0.3) ns
Repetition rate: 100 Hz
AOI: 56°
Polarization: Linear P
Beam diameter (1/e²): (225.8 ± 3.1) µm




## TFP FOR HIGH POWER ULTRAFAST LASER APPLICATIONS

Even though the most significant improvement of SUPERHERO POWER TFP is noticeable in nanosecond regime, ultrafast laser enthusiasts can also benefit from this OPTOMAN innovation:

| | | Measured LIDT values of SUPERHERO POWER POLARIZERS | |
|---|---|---|---|
| **Conditions** | **Market standard LIDT values for high power Polarizers** | **Linear S polarization** | **Linear P polarization** |
| **Picosecond:** 1030 nm, 10 ps, 10 kHz, AOI 56°; beam 113 µm; $10^5$-on-1 | 1.5 - 3 J/cm² | **4.94 J/cm²** | **3.3 J/cm²** |
| **Femtosecond:** 1030 nm, 500 fs, 10 kHz, AOI 56°; beam 180µm; $10^5$-on-1 | 0.3 - 0.6 J/cm² | **1 J/cm²** | **0.95 J/cm²** |

# IBS COATED WAVEPLATES

Waveplates, also known as retarders, are optical devices that alter the polarization of light as it passes through them. The primary function of a waveplate is to introduce a phase difference between the two orthogonal components of polarized light. OPTOMAN offers both λ/2 and λ/4 waveplates.

## Low-Order Waveplates

These waveplates operate at relatively low orders of interference, such as first or second order. They introduce a phase shift that is proportional to the wavelength of the incident light.

## Zero-Order Waveplates

Zero-order quartz waveplates involve two crossed quartz waveplates, yielding an effective retardation and thus minimizing the sensitivity to wavelength and temperature changes compared to some other types of waveplates.

Typical OPTOMAN waveplates feature:

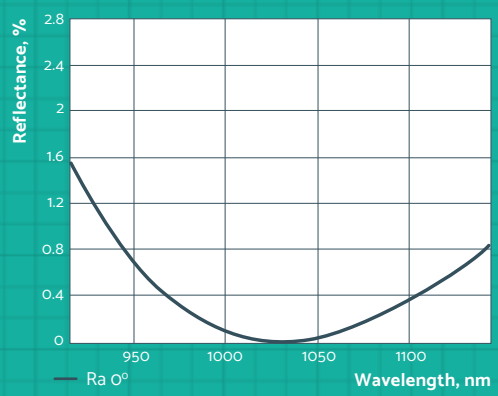
- Transmitted WFD: <λ/10 @ 633 nm
  Retardation and tolerance:
  ± λ/300 @ 20 deg C
- Surface quality: 20-10 S-D
- Beam deviation: <10 arcsec
- λ/2 and λ/4 options available

**OPTOMAN antireflective IBS coatings can be applied on both Low and Zero Order Crystalline Quartz Waveplates, which reduces the absorption and enhances the lifetime of these optics.**

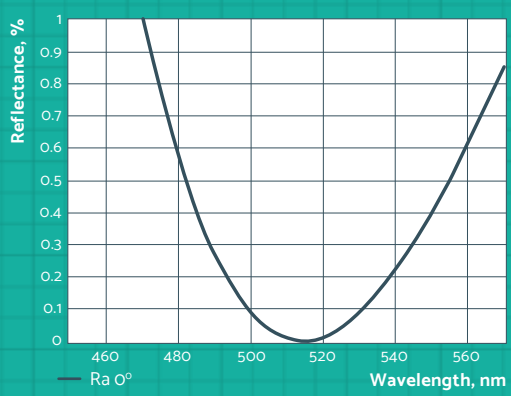
## Design examples

Below are spectral performance examples of coatings that can be applied on Crystalline Quartz Waveplates:

**AR<0.1% @ 1030 nm, AOI=0°**




**AR<0.1% @ 515 nm, AOI=0°**




## LOOKING FOR HIGH-POWER BEAM SHAPING SOLUTIONS?

CANUNDA BY CAILABS

OPTOMAN recommends Canunda by Cailabs - an innovative high-power beam shaping system that improves laser machining processes.

Cailabs Canunda is shaping the light using Superhero power OPTOMAN optics.

# UV OPTICS

**(most sensitive wavelengths due to multi-photon absorption phenomenon)**

Inspired by the challenges that industrial players in the micromachining market face, OPTOMAN has done quite a unique thing – optimized the IBS coating process to make low absorption and high longevity dielectric optical components for ULTRA VIOLE[n]T LASERS.

Main challenges that UV optics face:

- Low transparency due to absorption
- Scattering due to even tiny imperfections
- Laser damage and long-term degradation

## ENHANCED LIFETIME

Coatings made by OPTOMAN feature extremely **low absorption (reaching <1 ppm)** resulting in increased longevity of optics.

## WHY NOT METAL OR FLUORIDE COATINGS?

**Fluoride coatings:**

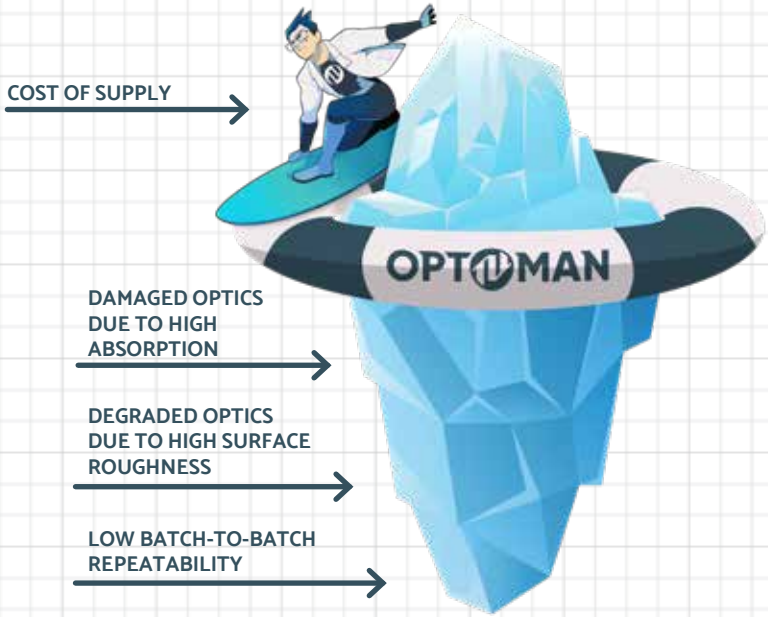
Soft coatings
↓
High surface roughness
↓
Scattering and rapid coating degradation

**Metal coatings:**

High absorption
↓
Heating
↓
Laser damage

**OPTOMAN is able to lower Total Cost of Ownership**

Laser optics made by OPTOMAN, due to low absorption, low surface roughness and high batch-to-batch repeatability, offer higher longevity than optics produced by others, thus lowering the Total Cost of Ownership and ensuring the cost of supply wouldn't be just the tip of the iceberg when purchasing optics.

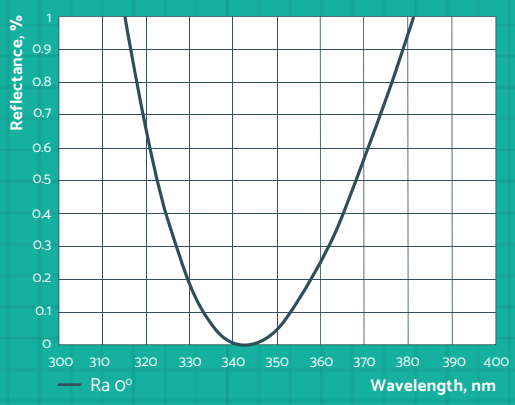


# ANTI-REFLECTIVE UV COATINGS

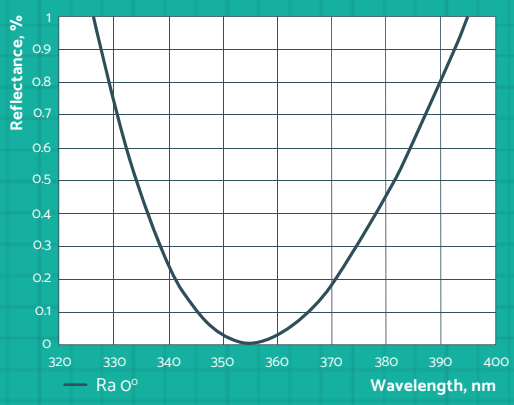
One of the main challenges that UV coatings face is low transparency due to absorption. This is, obviously, particularly evident in AR coatings. OPTOMAN, by mastering the IBS technology and using fluoride coatings, minimizes the absorption loss of AR laser optics and ensures stability in the UV and even the Deep-UV region.

## Design examples

**R<0.1% @ 343 nm, AOI=0°**




**R<0.1% @ 355 nm, AOI=0°**

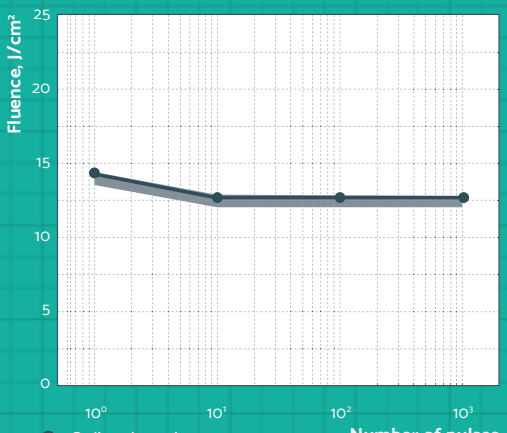



### Looking for SuperHero power?

**Superhero power coating technology is applicable for AR coatings @ 266 – 355 nm**

Measured LIDT: >12.66 J/cm² @ 355 nm, 6 ns, 100 Hz

Ongoing R&D towards LIDT target of >20 J/cm² @ 355 nm, 6 ns, 100 Hz




Wavelength: 355 nm
Pulse duration (FWHM): (5.6 ± 0.3) ns
Repetition rate: 100 Hz
AOI: 0°

Polarization: Linear
Beam diameter (1/e²): (223.4 ± 2.3) µm

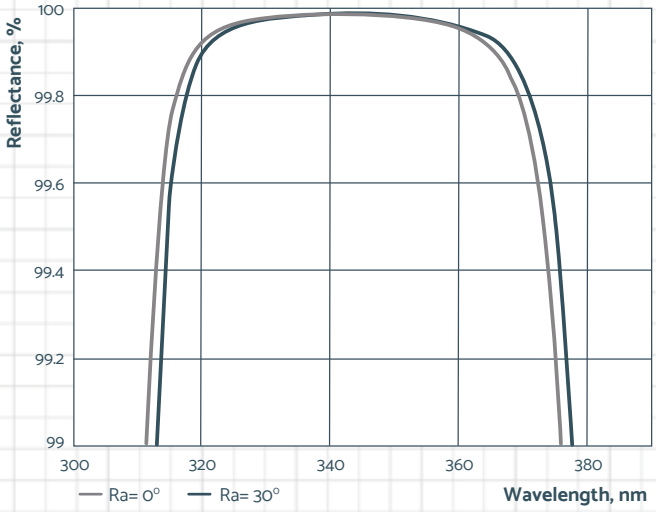
# HIGH REFLECTIVE UV COATINGS

High Reflective (HR) coatings are also affected by absorption, which can induce laser damage on coated optics. OPTOMAN deposits ultra hard dielectric coatings for high damage threshold in most demanding laser applications.

## Design examples

**Coatings (IBS):**

HR>99.9% @ 343 nm. AOI = 0 - 10°.

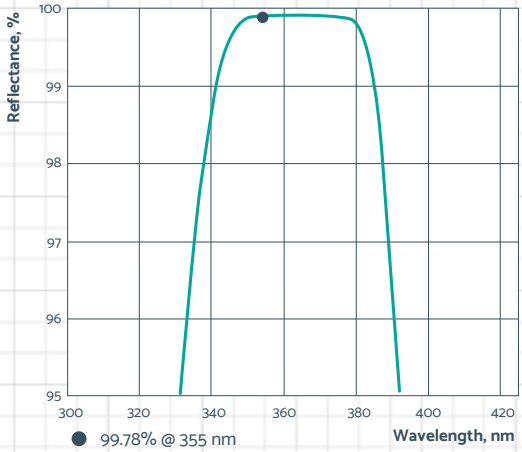



Get it at OPTOSHOP

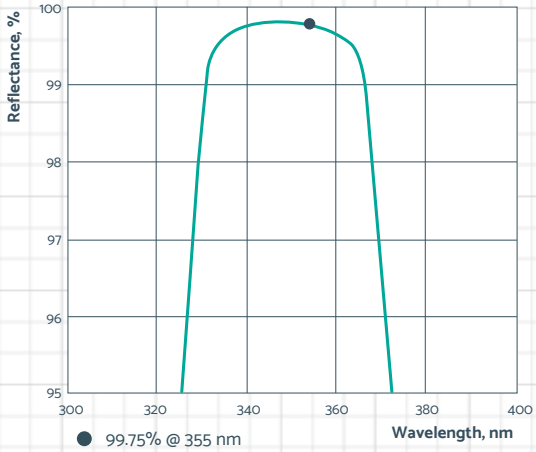
**Coatings (IBS):**

HRa > 99.7% @ 355 nm, AOI = 32-45°.

For high power nanosecond applications.

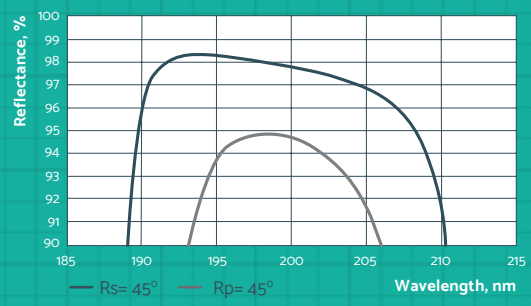



Measured average reflectance spectrum, AOI = 32°

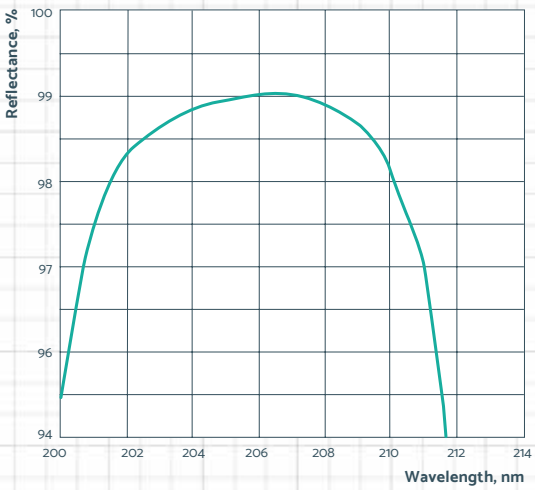



Measured average reflectance spectrum, AOI = 45°

HRs > 95% & HRp > 90% @ 196-200 nm, AOI=45°




HRa > 97% @ 206 nm, AOI = 45°



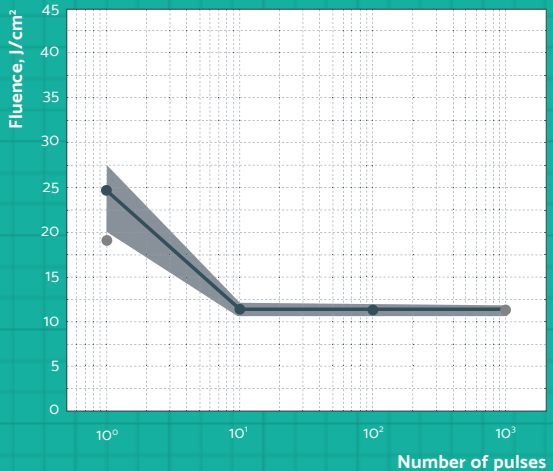

Get it at OPTOSHOP

## Looking for SuperHero power?

Laser damage is the arch-enemy of UV optics.

To fight it, one must measure it. So OPTOMAN does, for femtosecond and nanosecond scale.

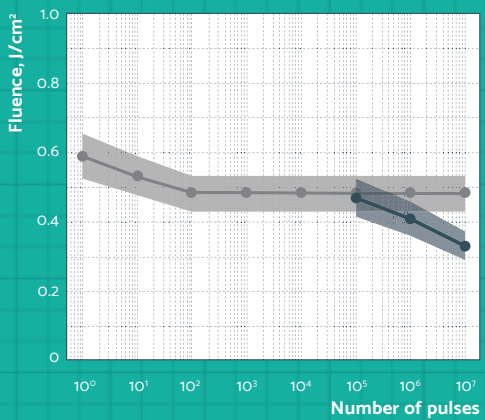
**HR @ 355 nm:**
LIDT: >11.20 J/cm² @ 355 nm, 6 ns, 100 Hz, s-pol,
$10^3$ – on – 1




- Offline detection
- Online detection
- 95% confidence interval

Wavelength: 355 nm
Pulse duration (FWHM): (5.7 ± 0.3) ns
Repetition rate: 100 Hz
AOI: 45°
Polarization: Linear S
Beam diameter (1/e²): (218.4 ± 3.3) µm

**HR @ 343 nm for ultrafast laser applications:**
LIDT (catastrophic): >0.484 J/cm² @ 343 nm, 300 fs,
$10^7$ – on – 1
LIDT (color change): >0.332 J/cm² @ 343 nm, 300 fs,
$10^7$ – on – 1




- Offline detection
- 95% confidence interval
- Color change
- 95% confidence interval

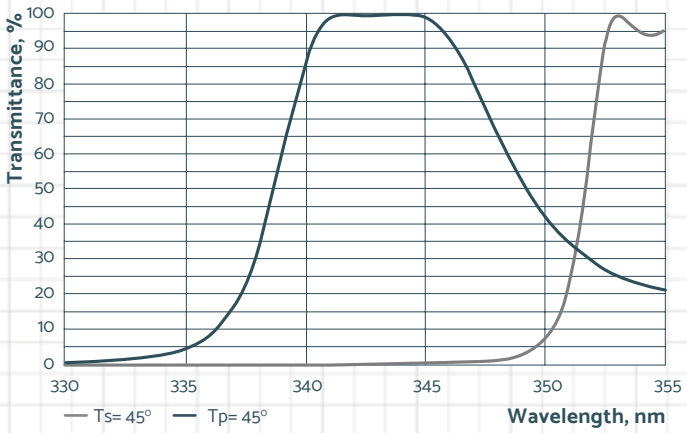
Wavelength: 343 nm
Pulse duration (FWHM): 300 fs
Repetition rate: 200 kHz
AOI: 45°
Polarization: Linear S
Beam diameter (1/e²): (19.5 ± 0.5) µm

# THIN FILM UV POLARIZERS

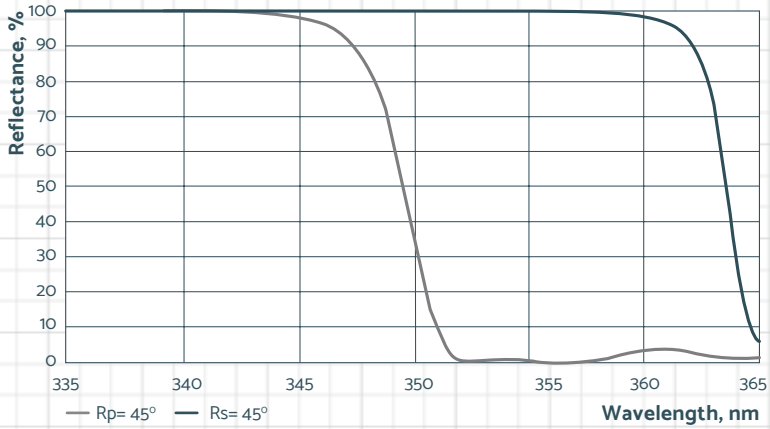
## Design examples

**Low Absorption Polarizer 343 nm**

**Coatings (IBS):**
S1: Rs>99.7% & Tp>95% @ 343 nm, AOI = 45° ± 2°
Extinction ratio: Tp/Ts>300:1



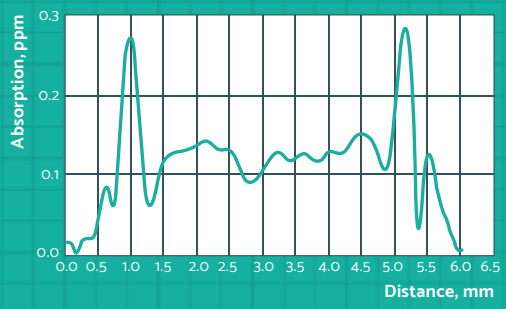

**Thin Film Polarizer 355 nm**
S1: Rs>99.8% & Tp>97% @ 355 nm, AOI=45° ± 1°



# LOW ABSORPTION COATINGS ON MICRO-OPTICS, FIBERS AND END CAPS

Small items like micro-optics that are a few micrometers in size are difficult to handle throughout the whole coating process, but OPTOMAN has made investments in equipment enabling repeatable process and the experienced and precise OPTOMAN squad has proven that no optics are too small for them to handle.

Now micro-optical systems as well as fibers and end caps can benefit from low absorption IBS coatings, which push the overall efficiency to new levels.




Absorption measurement@ 1064 nm. Low absorption is responsible for thermal shift-free performance and negligible fatigue of coated surfaces.

**Low absorption IBS coatings on fast axis collimators (FAC) minimize the unwanted effects originating from the heat generated by the laser diode.**

### Absorption loss <1 ppm per coated surface @ 1064 nm

Absorption is the main damage and fatigue driver. With absorption being at low level, AR coated Micro-optics feature enhanced duty cycle.

### Reflectance per surface down to R<0.01%

Sputtered anti-reflective coatings feature performance close to theoretical.

### High Laser-Induced Damage Threshold

OPTOMAN transmissive coatings can be optimized for high LIDT and feature values of >40 J/cm$^2$ @ 1064 nm, 10 ns, 10 Hz, $10^3$-on- 1.

### Temperature and humidity independent performance

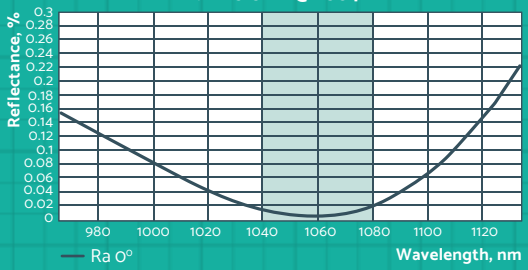
Durable, non-porous and near bulk IBS coatings increases the longevity and reliability of the system, eventually resulting in a lower total cost of ownership.

**OPTOMAN is flexible like your fiber and can adapt according to fiber length and bend radius.**

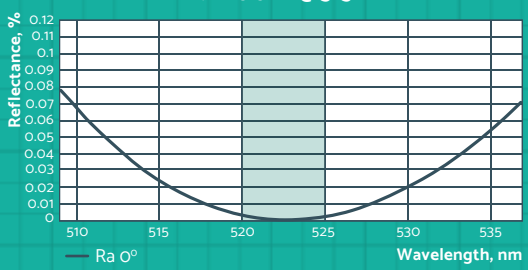
IBS is a “cold” coating deposition process in which the internal temperature does not exceed 150° C. Most anti-reflective coating processes stay below 100° C, which is useful for temperature-sensitive FC/PC connectors.

## Design examples

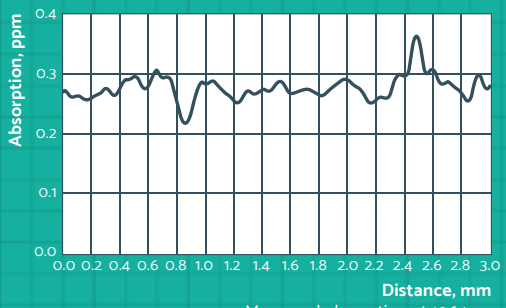
**AR < 0.01% @ 1064 nm**

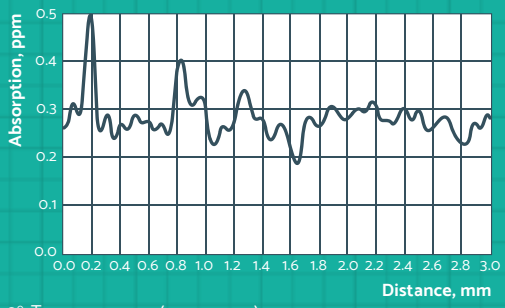



**AR < 0.01% @ 523 nm**

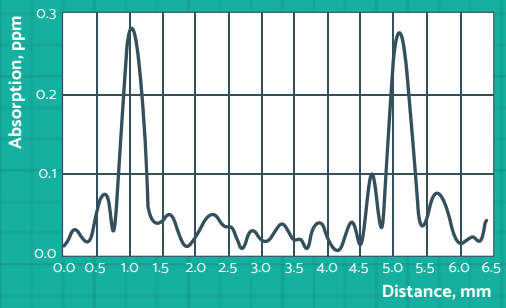


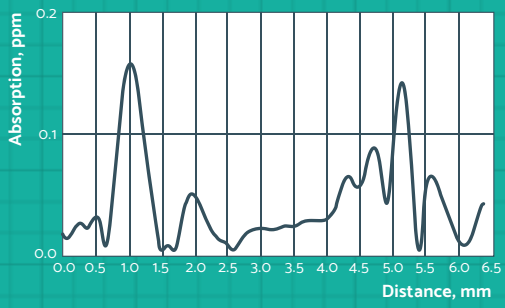

**AR<0.1% @ 1030 nm - 1090 nm & R<4% @ 500 nm - 700 nm, AOI=0°**




Measured absorption at 1064 nm at AOI=0°. Transverse scan (scan across).




Measured absorption at 1064 nm at AOI=0°. Longitudinal scan (scan through).

Note that OPTOMAN is not limited to AR coatings on micro-optics and fibers.

# COATINGS ON METAL SUBSTRATES

Inspired by optical challenges in beamshaping industry, OPTOMAN has developed the capablity to produce dielectric coatings on metal substrates with good adhesion.

**Why this dielectric - metal union is a good idea?**

Many diamond-turned metals have very high infrared reflectivity and corresponding low absorption. But, with the restriction of the optical constants of the metal material, the reflectivity couldn't be large enough. So the reflectivity of the metal surface must be improved by depositing multi-layer dielectric films. Dielectric coatings can reduce absorption, increase the laser damage threshold, and improve surface durability. Metal reflectors with high reflectivity resulting from high quality dielectric coatings and good thermal conductivity could improve the resistance to laser irradiation in high-power laser systems.

**Metal coatings:**

High absorption

↓

Heating

↓

Laser damage

IBS coatings are available on Nickel, Aluminum, Copper, Stainless steel and other metal substrates;

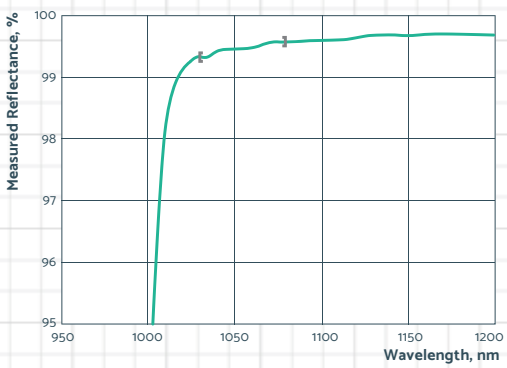
Dielectric coatings of OPTOMAN get along with metal substrates - good adhesion was one of the main product development elements.

High reflectance of >99% for diamond turned components in wide-angle range.

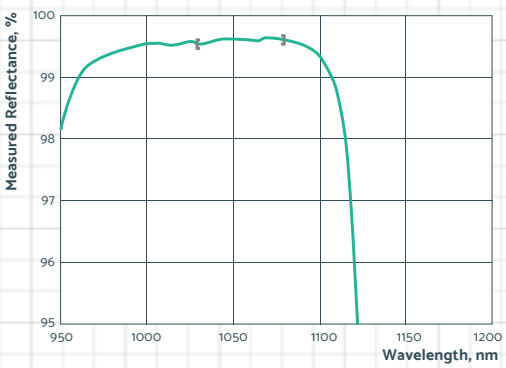
Coated elements have an excellent surface quality of 10/5.

## Design examples

**IBS coating on diamond turned Aluminum substrate:**
**HRa>99.9% @ 1030-1080 nm, AOI=22.5-50°**




avg = 99.46% @ 1030 - 1080 nm, AOI = 22.5°




avg = 99.60% @ 1030 - 1080 nm, AOI = 50°

## WHERE DOES OPTOMAN WORK?

OPTOMAN spends a significant amount of time in manufacturing facilities, therefore he wants to show you how does his 270 m² ISO7 certified workplace look like and what are the key processes that allow him to offer you top-notch optical components.

### Preparation of substrates

Firstly, thorough preparation of substrates is needed in order to make quality optical coatings as you don't want to start the coating process on unclean substrates:

OPTOMAN uses a 7-stage fully automated cleaning process, which makes the preparation of substrates efficient and effective.

### Coating deposition

As with great laser power comes great responsibility for coaters, OPTOMAN uses only the most advanced thin film deposition technology – Ion Beam Sputtering (IBS), which allows him to exploit his superpowers. IBS has the same meaning to OPTOMAN as Mjölnir hammer has to Thor. So yes, it's pretty important and OPTOMAN does not shy investments to have the best IBS machines in order to provide the best optics. The area where IBS machines are is extra clean, meeting the requirements of ISO 5.

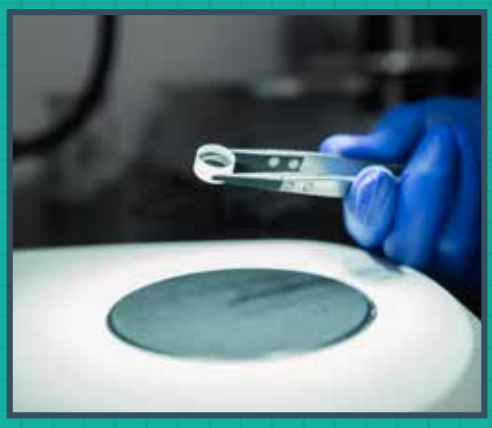
## LOOKING FOR ROBUST MIRROR MOUNTING SOLUTIONS?

PHOTONICPARTS

OPTOMAN recommends highly precise and robust mounting and packaging solutions from PHOTONICPARTS.

## Quality inspection and metrology

OPTOMAN doesn't call optical components high quality by default. Measurements and inspections are needed to define the quality. OPTOMAN is equipped to do it.



## Final optical component

Ta-da! OPTOMAN optics are ready to fulfill their purpose – become friends with your laser beam.

## R&D ACTIVITIES

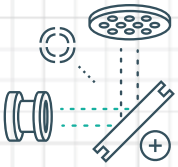
- OPTOMAN heavily invests in R&D activities.
- OPTOMAN cooperate with leading research institutions for extensive characterization and proof of concepts.

## Ongoing R&D projects:

- INTENSITY – Development of low total loss coatings for VIS-NIR range.
- UNIPULSE – Development of high LIDT coatings for ps-fs applications for VIS-NIR range.
- INOSTART – Development of MID-IR (1–5 µm) coatings based on oxide / semiconductor materials.
- Neo2Fast – Development of broadband mirrors with High LIDT performance for multi-pass cells sub-10 fs applications.

**"INTELLIGENCE IS A PRIVILEGE, AND IT NEEDS TO BE USED FOR THE GREATER GOOD OF LASER PEOPLE."**

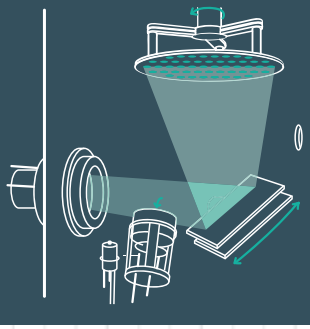
Dr. Otto Octavius



# ABOUT ION-BEAM SPUTTERING TECHNOLOGY

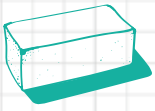
Ion Beam Sputtering (IBS) is a technique when the layer of a desired material is formed by molecules extracted from the target material by a highly energetic and precisely controlled ion beam.

As with great laser power comes great responsibility for coaters, OPTOMAN is equipped by IBS machines in order to meet the most demanding requirements from most demanding industrial and scientific applications.

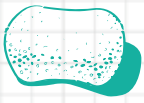


**Inherently stable sputtering process**

A very stable ion beam combined with high vacuum (~1x10$^{-4}$ mbar during the deposition) and ultra-high purity metal targets (>99.99%) result in a super stable deposition process. It enables a fully automatic deposition and the ability to precisely control refractive indices and thicknesses of each deposited layer.



**IBS**
Near Bulk Density



**E-beam**
Porous Structure

**Bulk-like packing density**

Due to the bulk-like layer's density, IBS coatings are completely immune to mechanical wear as well as changes in ambient temperature and humidity and ensure smooth operation of your laser under any circumstances. Moreover, OPTOMAN coatings may be used in harsh environments and even in outer space with no change in performance!

**Scattering? What's that?!**

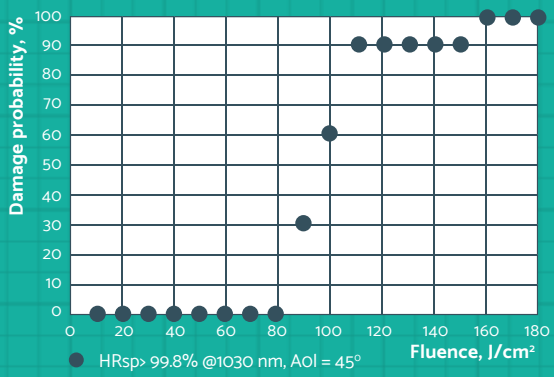
Due to the near-bulk IBS coating density, the surface roughness of the coated component is mainly determined by the initial substrate roughness. Combine this with the completely amorphous coating layers and you will end up with almost scatter-free optics!

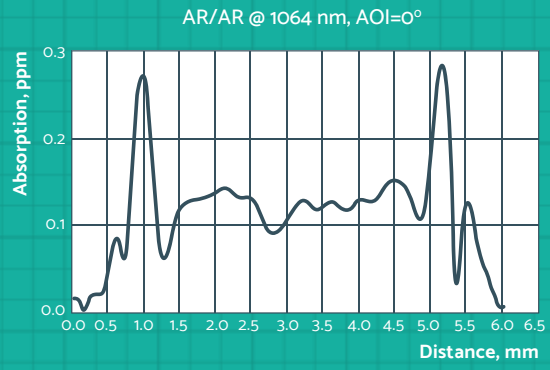
**IBS**

**E-beam**

### High resistance to laser irradiation

By choosing proper deposition parameters and ensuring cleanliness in every step of the manufacturing chain, OPTOMAN is able to produce coatings with very low defect densities. That is the reason why IBS coatings exhibit excellent resistance to laser irradiation!




### Forget short duty cycle issues!

It is well known that absorption losses are the main cause of thermal effects and a short duty cycle. A high and stable vacuum, extremely pure target materials, near bulk coating density, spatially separated sputtering and material condensation processes allow to form almost contamination-free layers with the absorption losses bellow 2ppm.

If you use high repetition rate fs, or a CW system and longevity is your concern, give OPTOMAN coatings a try and you will be surprised!

## IBS FAMILY

Currently OPTOMAN has 5 IBS machines, each of them is specialized in a specific set of superpowers and has a unique Marvel character name. Well almost all of them, at the time of writing this sentence, we are waiting for the 5th machine to be named....

### PETRA

**Effective coating area:**
ø270 mm x 2 pallets

**Superpowers:**
- Universal
- Super efficient
- Extreme low loss coatings

### HYPERION

**Effective coating area:**
ø270 mm x 2 pallet

**Superpowers:**
- Universal
- Super efficient
- Extreme low loss coatings

### TBD

**Effective coating area:**
ø270 mm x 2 pallet

**Superpowers:**
- Universal
- Super efficient
- Extreme low loss coatings

### ALBERT - THE ATOM SMASHER

Effective coating area:
ø600 mm x 2 pallets

**Superpowers:**
- Ability to coat big optics
- Volume production

### WANDA - SCARLET WITCH

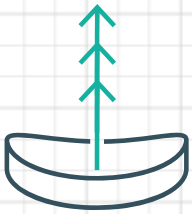
Effective coating area:
ø270 mm x 1 pallet

**Superpowers:**
- Mid-IR coatings
- Extreme low loss coatings

## SUSTAINABLE PRODUCT LIFECYCLE

OPTOMAN acts responsibly during the whole product lifecycle.

It starts from the thorough selection and assessment of suppliers according to OPTOMAN values.



OPTOMAN has optimized production processes to ensure a high yield of production and clean optics.

OPTOMAN also reuses optical components not compliant to specifications by repolishing them to limit waste.

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# OPTOMAN

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LASER OPTICS DEVELOPMENT

## OTHER CAPABILITIES






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