# OPTICS FOR MEDICAL LASER APPLICATIONS

OPTOMAN

YOUR SIDEKICK FOR
LASER OPTICS DEVELOPMENT

# TABLE OF CONTENTS

# HIGHLY CUSTOMIZED AND APPLICATION OPTIMIZED LASER OPTICS FOR DEMANDING APPLICATIONS FROM DEMANDING MARKETS

Optics for DPSS Lasers

Optics for Medical Laser Systems

Optics for Ultrafast Lasers

Optics for Defense Applications and LIDARs

Optics for multi kW Laser Systems

Optics for micromachining and macromachining systems

Research & Developement

Optics for Inspection Measurement and Diagnostics Systems

Optics for Biomedical Applications

# 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

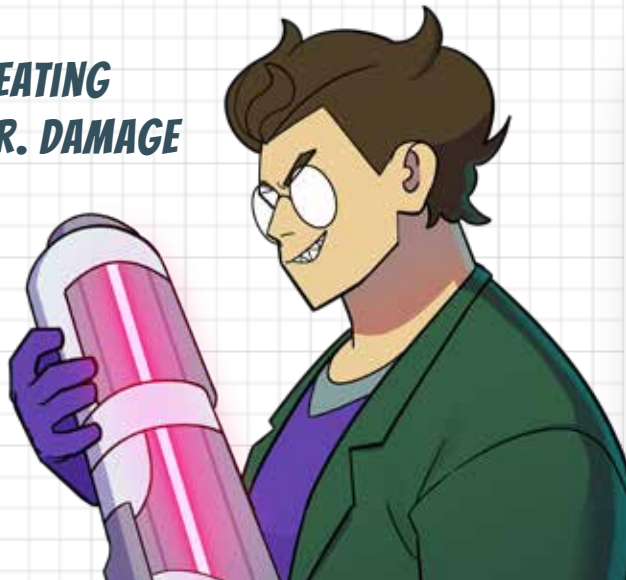
**High reflectance coatings:**
> 2.58 J/cm² @ 1064 nm, 370 ps, 20 Hz, 2.4 mm
> 1.64 J/cm² @ 532 nm, 350 ps, 20 Hz, 2.1 mm
> 8.313 J/cm² @ 1030 nm, 10 ps, 1 kHz, 154 µm

**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.

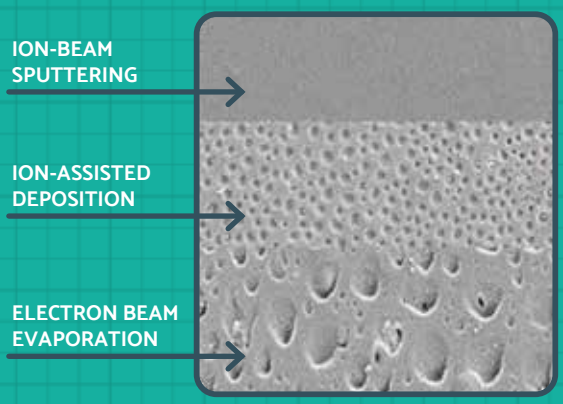
## BEATING DR. DAMAGE



# OPTICS FOR MEDICAL LASER APPLICATIONS

Working hand to hand with the biggest medical laser manufacturers, OPTOMAN has developed an application-optimized products, which increases the **longevity and reliability** of our partners' laser systems, eventually resulting in a lower total cost of ownership.

## Why OPTOMAN?

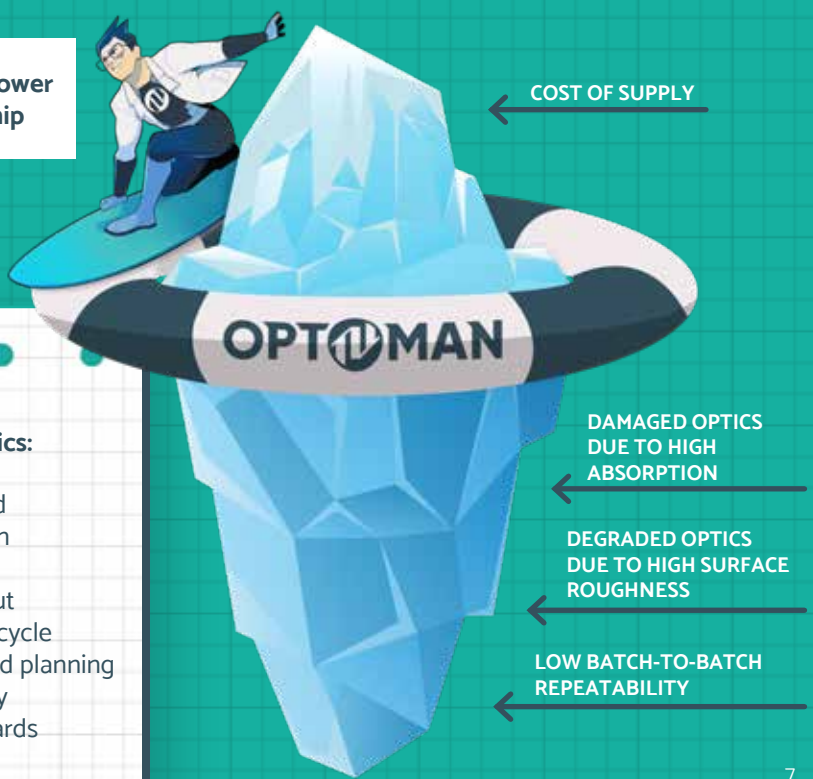



As with great laser power comes great responsibility for coaters, OPTOMAN solves your problem with ultrafast turnaround and uses only the most advanced thin film deposition technology – Ion Beam Sputtering (IBS).

IBS coatings have bulk-like layer density, thus have low absorption and are immune to spectral shifting, mechanical wear, changes in ambient temperature and humidity. That's why OPTOMAN ensures optics longevity and reliability.

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.

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




**OPTOMAN characteristics:**

- ISO 9001:2015 certified
- Collaborative and open innovation culture
- Sustainable throughout the whole product lifecycle
- Extensive technical and planning resources and capacity
- Flexibility leading towards scalable business

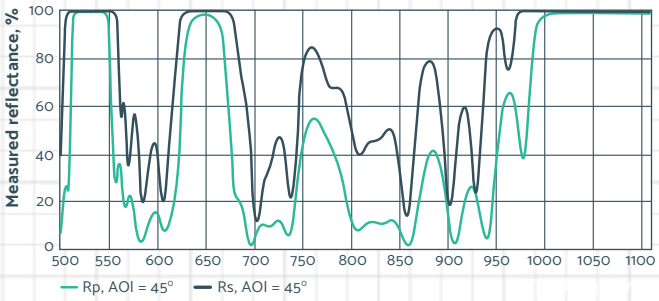
# MULTI-WAVELENGTH MIRRORS

**Some features:**

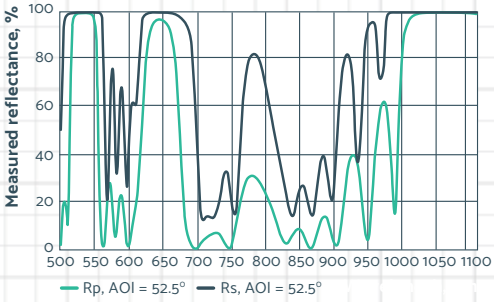
- Low accumulated transport loss
- Phase-shift optimization to maintain polarization
- Lidt optimized

## Design examples optimized for high LIDT

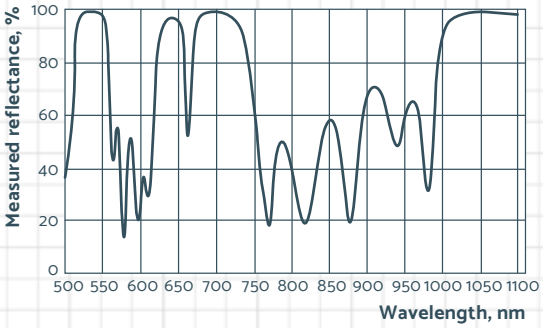
HRs>99.9% & HRp>99.4% @ 1064 nm
HRs>99.8% & HRp>99.5% @ 532 nm
HR>95% @ 635-650 nm, AOI=45°



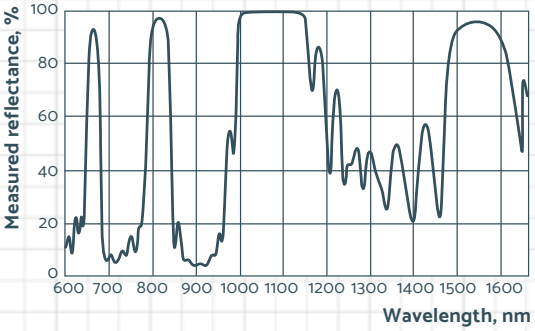

HRs & HRp>99.8% @ 1064 nm + 532 nm +
HR>96% @ 650 nm, AOI=52.5°




HR>98.0% @ 1064 nm
HR>98.5% @ 694 nm
HR>98.5% @ 532 nm
HR>87.7% @ 635 nm, AOI=45°

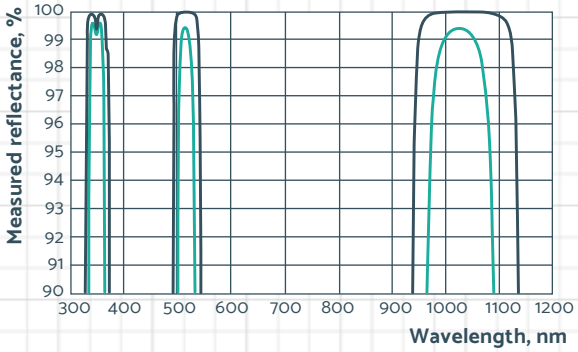



HR> 99.97% @ 1070 nm
HRa> 95% @ 1550 nm
HR> 85% @ 660 nm, AOI=45°



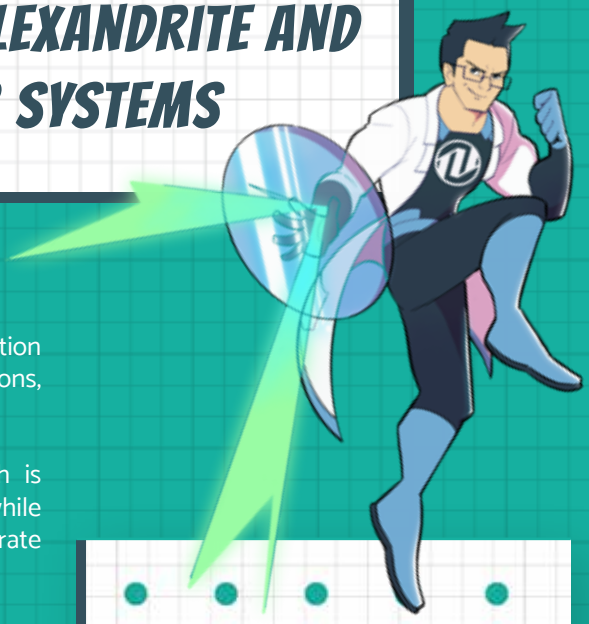

## Design examples optimized for ultrashort pulse applications

HRs & HRp>99% @ 1030 nm + 515 nm + 355 nm + 343 nm, AOI=45°
IGDD Rs&Rpl<20 fs²




**YOUR LASER IS AS DURABLE AS ITS WEAKEST LINK!**

# OPTICS FOR ALEXANDRITE AND ND:YAG LASER SYSTEMS



Alexandrite and Nd:YAG laser configuration is extremely useful for aesthetic applications, especially hair removal treatments.

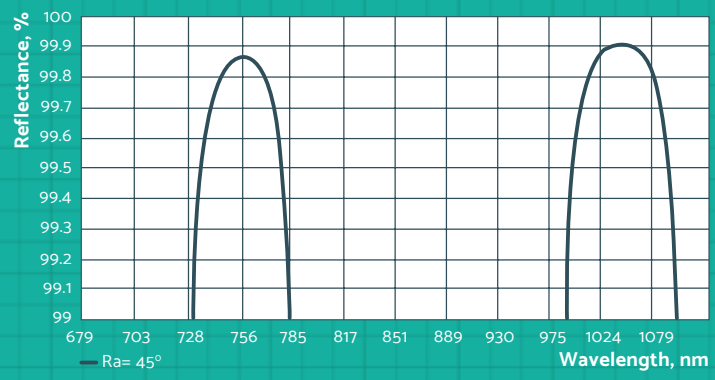
Alexandrite, which emits 755nm wavelength is very effective for fine and fair hair removal, while Nd:YAG laser with its 1064nm helps to penetrate deeper into the skin for better results.

By understanding the application deeply, OPTOMAN can boost the laser system effectiveness by **reducing the downtime** related to heating as IBS coatings feature very low absorption.

OPTOMAN optics feature **excellent ROI** and **low cost of ownership.**

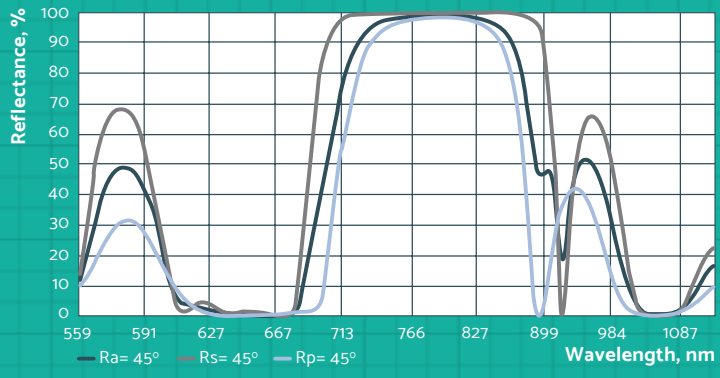
**Dual-Wavelength Mirror**

HR>99.8% @ 755 nm + 1064 nm, AOI=45°




**High Power Dichroic Mirror**

HRs > 99% @ 755 nm + HTsp > 98% @ 1064 nm +
T > 50% @ 650-670 nm, AOI = 45°

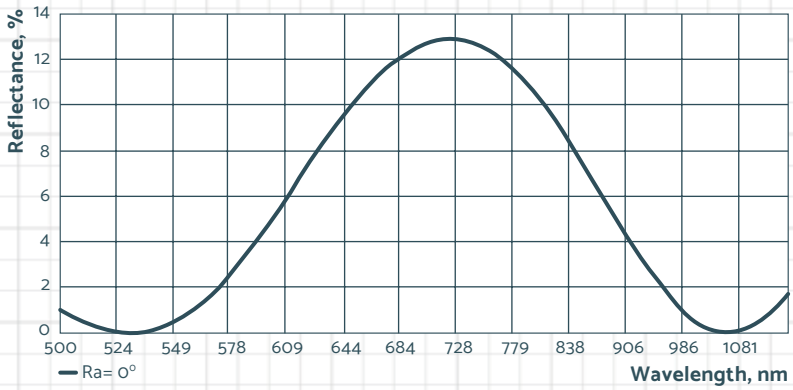



**LIDT:**
>7 J/cm² @ 750-760 nm, 10 ns pulses;
>10 J/cm² @ 1064 nm, 10 ns pulses.

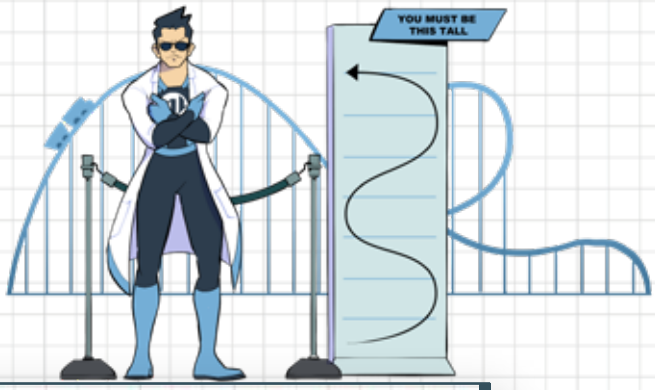
# OPTICS FOR NS/PS LASER SYSTEMS

**High Power Protective Window**

Ru<0.1% @ 1064 + Ru<0.1% @ 532 nm + AR<10% @ 635 nm, AOI=0-2°

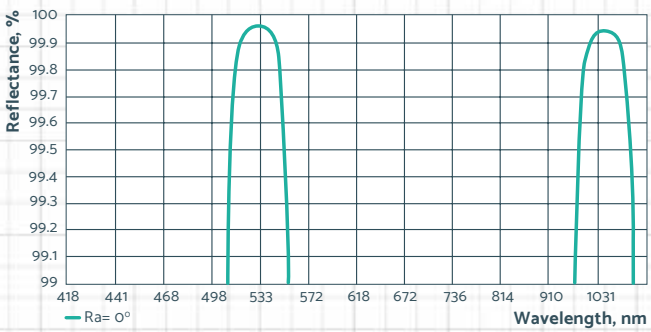



Medical Laser systems using 1064 and 532 nm wavelengths at both nanosecond and picosecond emission modalities are very effective for aesthetic applications such as **benign pigmented lesions, tattoo removal, and scar treatments**.




**Dual-Wavelength Mirror**

HR>99.85% @ 1064 nm + 532 nm, AOI=0°




**LIDT:**

>2 J/cm² @ 1064 nm, 300 ps

>1 J/cm² @ 532 nm, 300 ps

These laser systems use ultra-short and high power pulses to reduce thermal action. Picosecond pulses are very harsh on optical components so special attention to optics laser irradiation resistance has to be taken in order to improve the power of the system.

OPTOMAN has optimized coating design specifically for high power picosecond lasers and demonstrated **>5 J/cm², 1030 nm, 10 ps** laser induced damage threshold value.

# OPTICAL ASSEMBLIES WITH CUSTOM IBS COATINGS

Reliable, low absorption (<1ppm) and high LIDT IBS coated laser components can be assembled together according to specific optical design.

## CORE COMPETENCE

- Low-outgassing glues;
- Possibility of cementing;
- Custom assemblies;
- Adaptation to specific optical design;
- Assembly development;
- Possibility for low quantities.

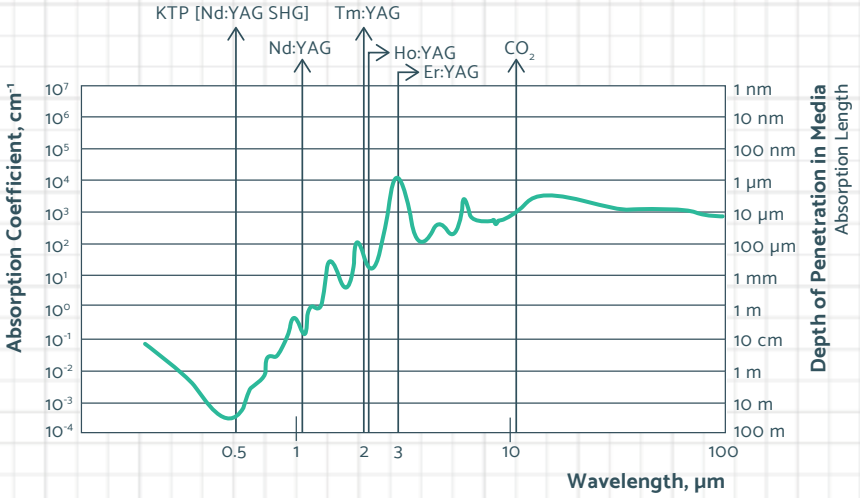
## LOOKING FOR ROBUST MIRROR MOUNTING SOLUTIONS?

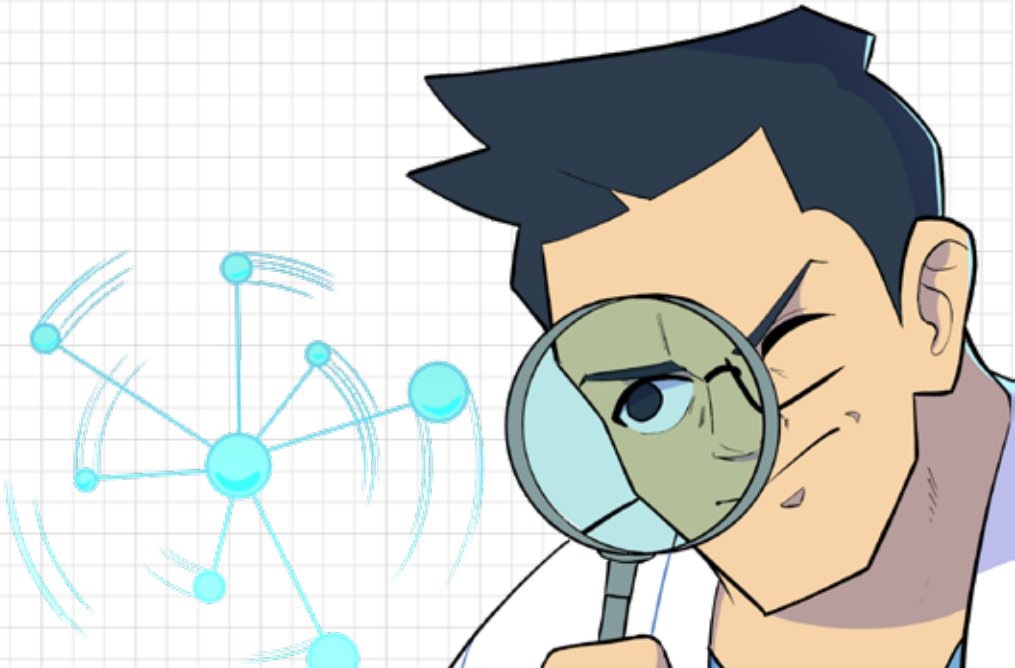
PHOTONICPARTS

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

# LOW ABSORPTION COATINGS FOR HO:YAG, TM:YAG AND ER:YAG LASERS

Holmium, Thulium, and Erbium-doped YAG lasers find a perfect spot in several medical applications. Emitted wavelengths of these lasers match water absorption peaks, which makes them helpful tools to perform procedures, where deep penetration of tissues is not desired.
What makes these lasers perfect for medical applications, gives a lot of headaches for laser optics manufacturers because water absorption significantly lowers LIDT values. After several rounds of intense R&D, OPTOMAN introduces a few high-power optimized design examples.

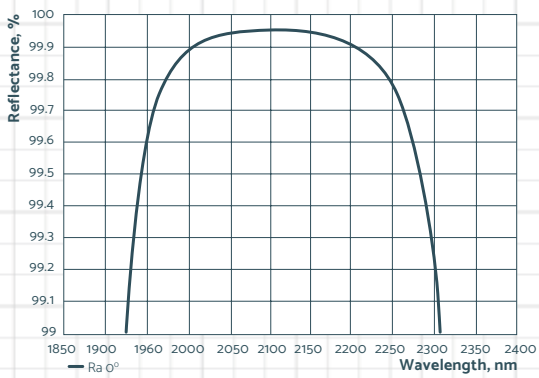


# COATINGS FOR HO:YAG AND TM:YAG LASERS

### LIDT Optimized Cavity Mirrors

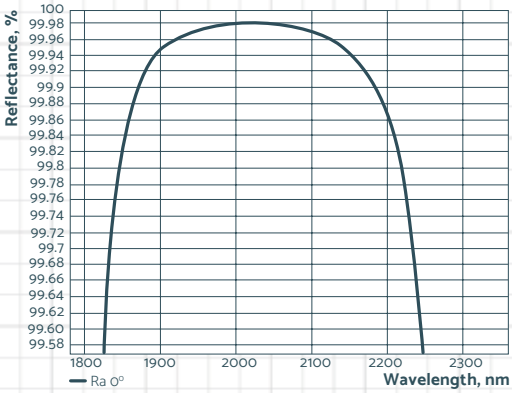
HR>99.9% @ 2100 nm, AOI=0°




Coating code: LLM57

### Broadband Bending Mirror

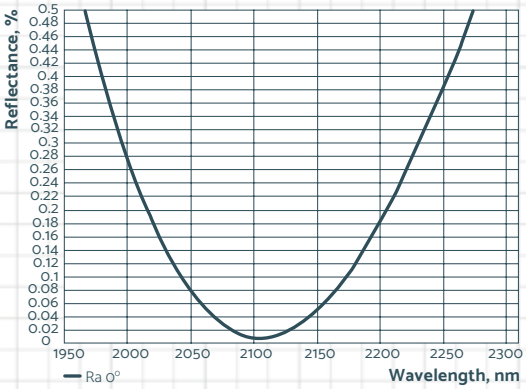
HR>99.9% @ 1900 nm – 2100 nm, AOI=0°




Coating code: BBHR17

### LIDT Optimized Cavity AR Coated Lenses

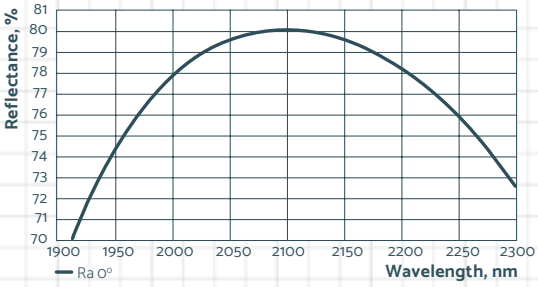
AR<0.1% @ 2100 nm, AOI=0°




Coating code: AR269

### LIDT Optimized Output Coupler

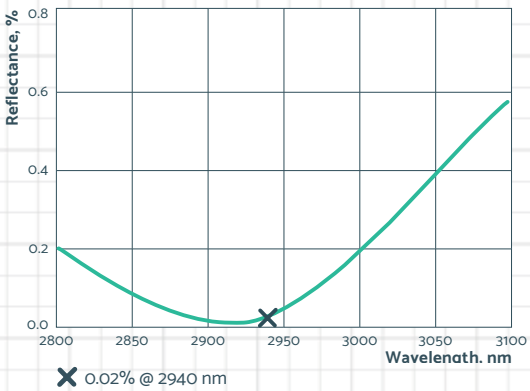
PR=80% +/- 1% @ 2100 nm, AOI=0°




# COATINGS FOR ER:YAG LASERS

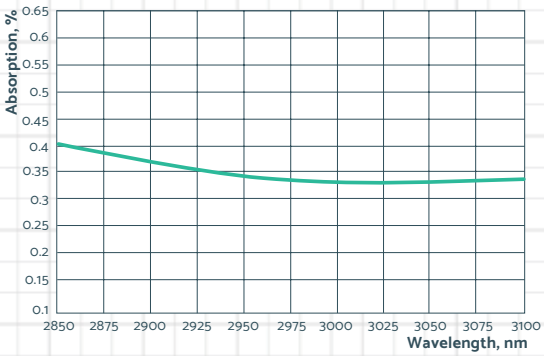
### Sapphire AR/AR Coated Window

AR<0.1% @ 2940 nm, AOI=0°




✕ 0.02% @ 2940 nm

Typical residual reflectance graph per single surface.



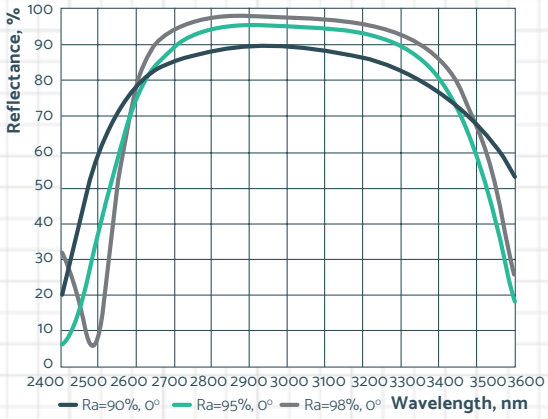

Measured absorption per AR@2940 nm coated surface.

### Output Couplers

PR=90% +/-1% @ 2940 nm, AOI=0°

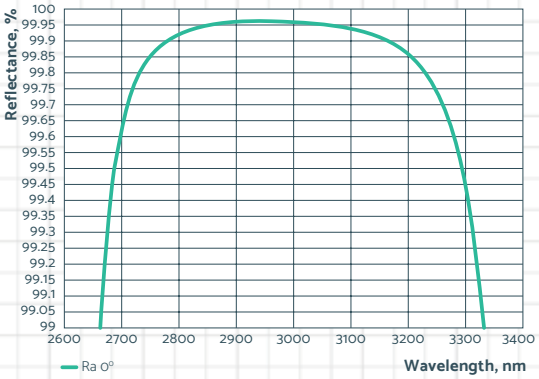
PR=95% +/-1% @ 2940 nm, AOI=0°

PR=98% +/-0.5% @ 2940 nm, AOI=0°



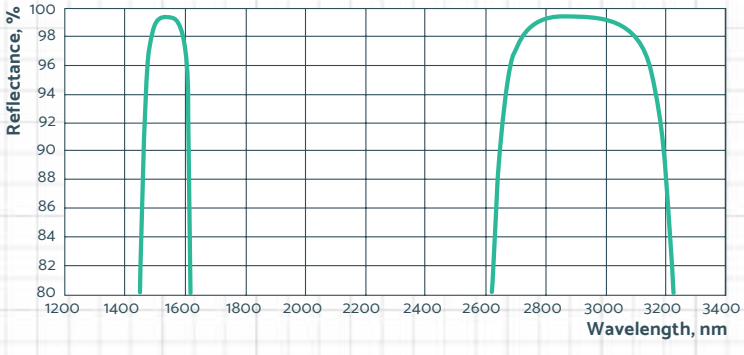

### Cavity Mirror

HR>99.9% @ 2940 nm, AOI=0°




### Multi Wavelength Bending Mirror

HR>99% @ 2940 nm + HR>99% @ 1535 nm + Ta>20% @ 635 nm, AOI=0°



# WHERE DOES OPTOMAN WORK?

OPTOMAN spends a significant amount of time in manufacturing facilities, therefore he wants to show you how does his 270 $m^2$ 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:

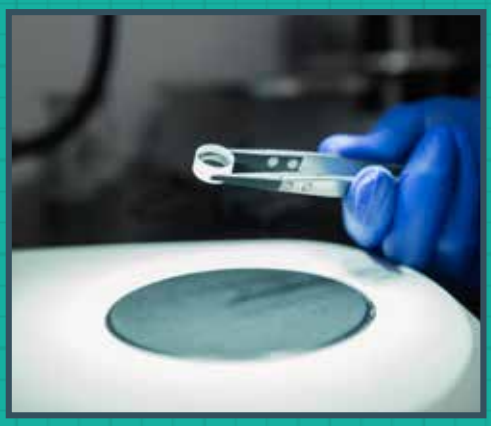
OPTOMAN uses a 7-stage fully automated cleaning process, which makes the preparation of substrates efficient and effective.

## 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.

## 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

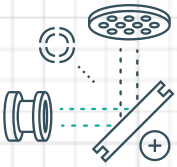
- OPTOMAN heavily invests in R&D activities.
- OPTOMAN cooperate with leading research institutions for extensive characterization and proof of concepts.

### 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."**

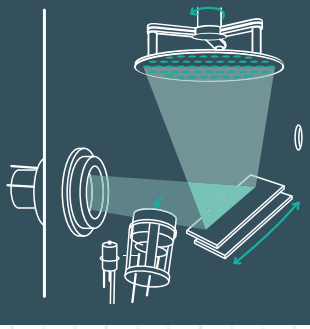
Dr. Otto Octavius



# ABOUT ION-BEAM SPUTTERING TECHNOLOGY

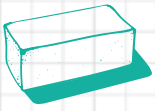
Ion Beam Sputtering (IBS) is a technique when the layer of a desired material is formed by molecules extracted from the target material by a highly energetic and precisely controlled ion beam.

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.

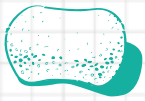


**Inherently stable sputtering process**

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?!**

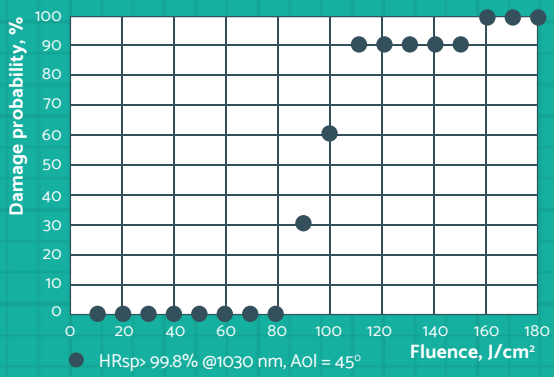
Due to the near-bulk IBS coating density, the surface roughness of the coated component is mainly determined by the initial substrate roughness. Combine this with the completely amorphous coating layers and you will end up with almost scatter-free optics!

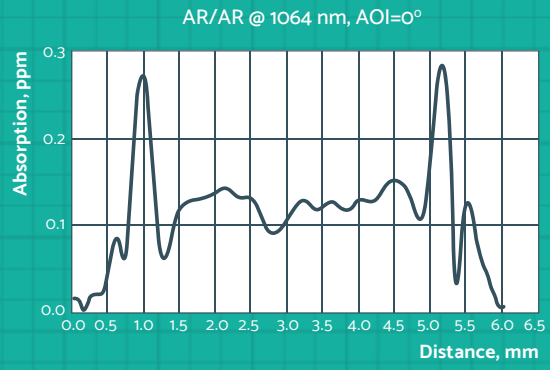
**IBS**

**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

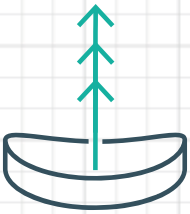
Effective coating area:
ø270 mm x 1 pallet

**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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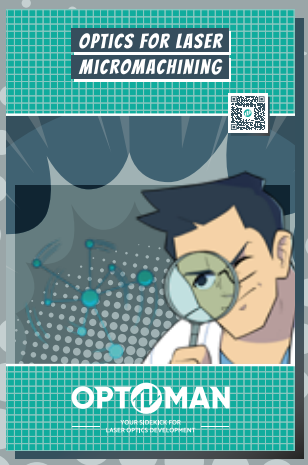
# OPTOMAN

YOUR SIDEKICK FOR
LASER OPTICS DEVELOPMENT

## OTHER CAPABILITIES








## CONTACT US

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