High Performance Laser Mirrors

produced with

Plasma-Assisted Reactive Magnetron Sputtering

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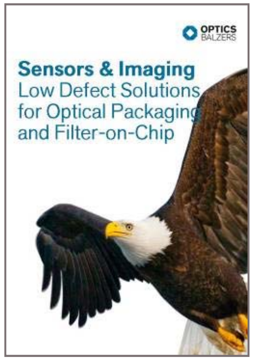
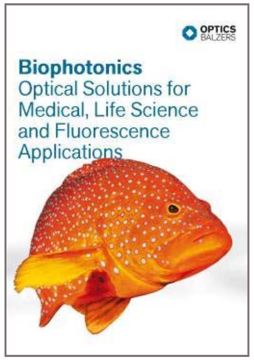
Sensors & Imaging

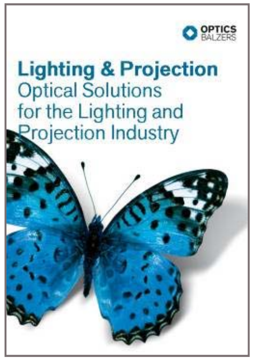


Laser, Space & Defence

Biophotonics



Lighting & Projection



Automotive

Components for Laser Applications

Laser, Space & Defence

Anti-Reflective:

- windows
- laser and non-linear crystals

Filters & Polarizers:

- laser line cleaning
- Raman edge & bandpass filters
- color-corrected laser line suppression
- thin film polarizers

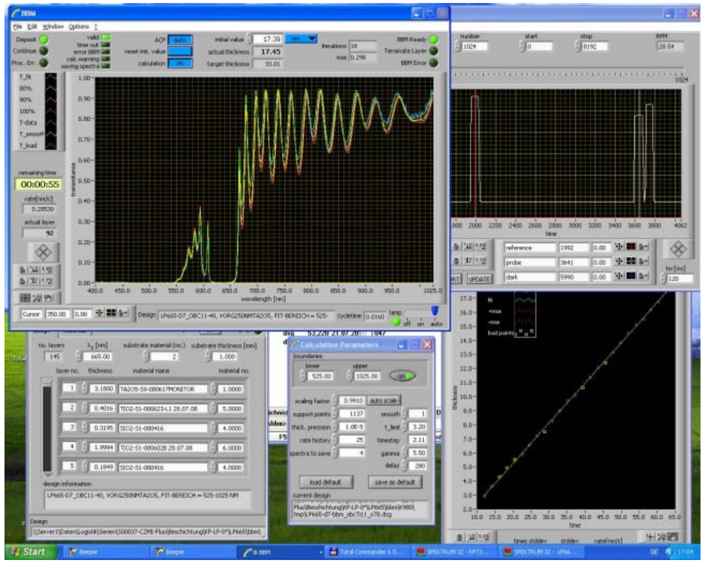
Mirrors:

- low-loss cavity mirrors
- dichroics
- high LIDT (CW, ns & ultrashort pulse applications)

Coating Processes

Laser, Space & Defence

- Ion-Assisted Deposition
- Ion-Beam Sputtering
- Magnetron Sputtering

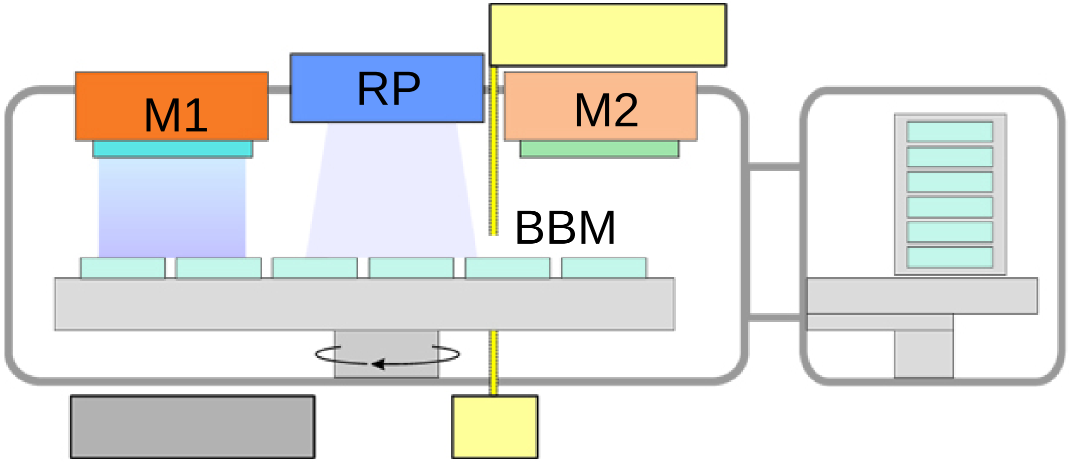


All Processes controlled via VIS/NIR Optical Broadband Monitoring

Plasma-Assisted Reactive Magnetron Sputtering

Laser, Space & Defence

- Bühler Leybold Optics Helios plants
- dual magnetron + oxidizing plasma source
- flexible choice of layer materials:
  SiO_2, Nb_2O_5, Ta_2O_5, HfO_2, Al_2O_3

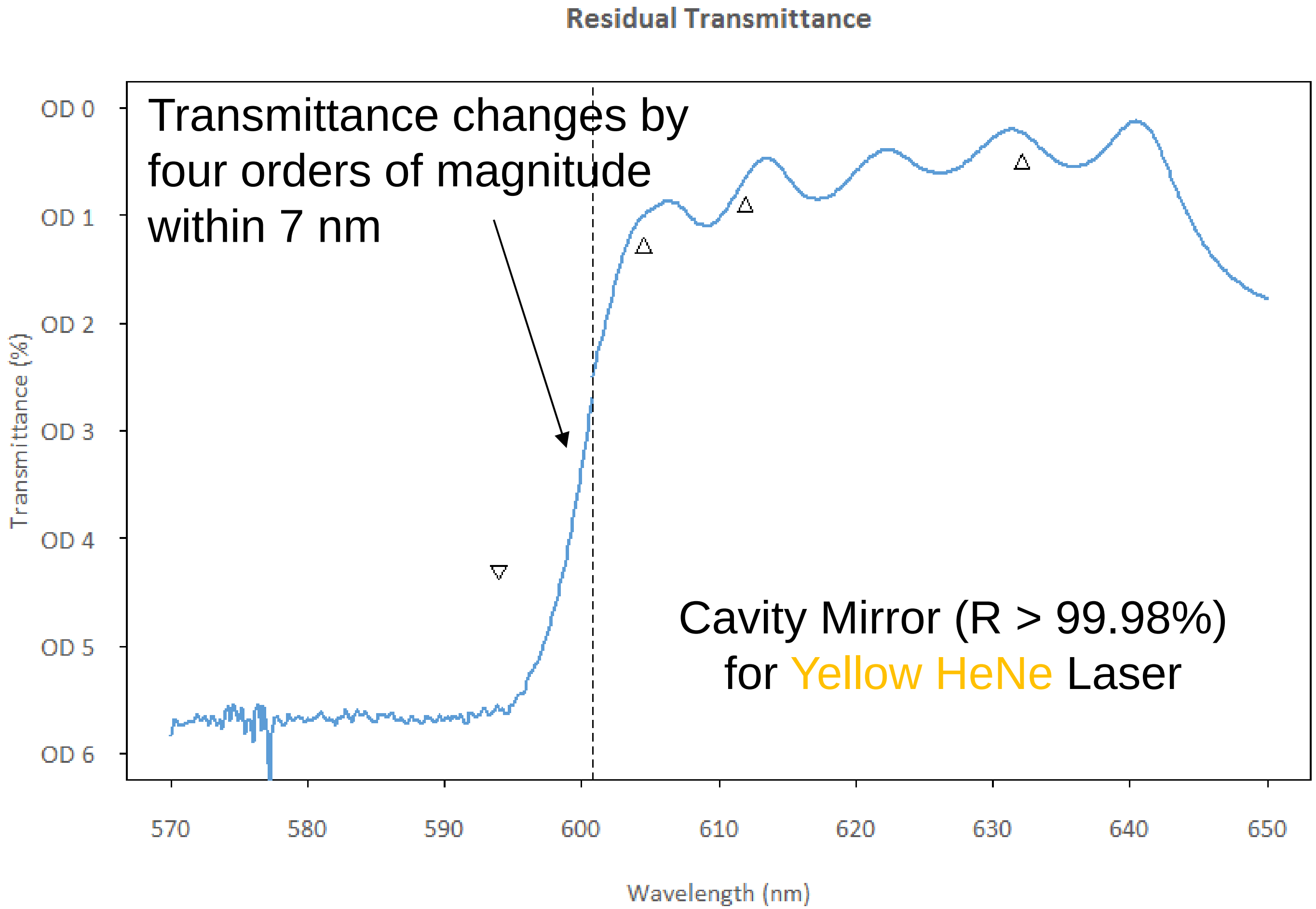


Significantly improved LIDT using RF magnetron technology for deposition of SiO_2 from ceramic target

→ H.Hagedorn, *Sputtered interference filters with high laser damage threshold*, OIC 2013 FB.2

Complex Mirror Characteristics enabled by BBM

Laser, Space & Defence



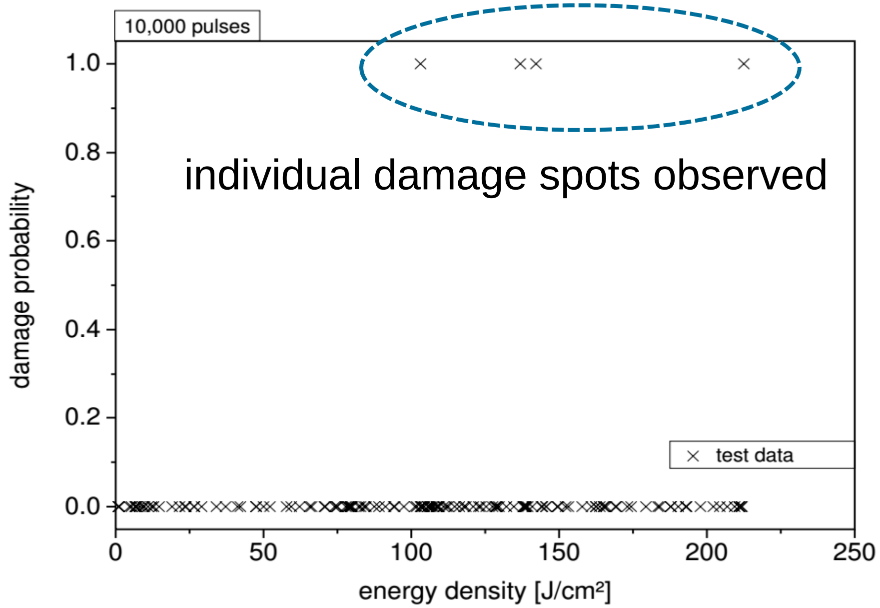
BBM enables complex suppression requirements for competing transition lines.

LIDT at 1064nm

Laser-induced Damage Threshold S-on-1 measurement according to ISO 21254-2

Wavelength	1064 nm
Operating mode	pulsed @ 100 Hz
Pulse duration	12 ns (FWHM)
Beam diameter	322 µm ($1/e^2$), 227 µm (effective)
Spatial beam profile	approx. gaussian
AOI	$(0 \pm 1)°$
Polarization	linear
Number of test sites	154
Spot matrix	hexagonal close-packed
Distance of the spot sites	$\Delta = 1{,}5$ mm
Online detection system	scattered light by Si-photodiode
Offline detection system	Nomarski microscopy (magnification $\leq 200\times$)
Environmental conditions	air
Mounting of optical components	commercial kinematic mount

Key feature: Laser Damage Threshold at 1064nm



Number of pulses	First observed damage [J/cm²]
2	213
5	103
13	103
34	103
88	103
230	103
580	103
1,500	103
3,900	103
10,000	103

Wavelength	1064 nm
Operating mode	pulsed @ 100 Hz
Pulse duration	12 ns (FWHM)

LIDT not measurable:
insufficient laser power!

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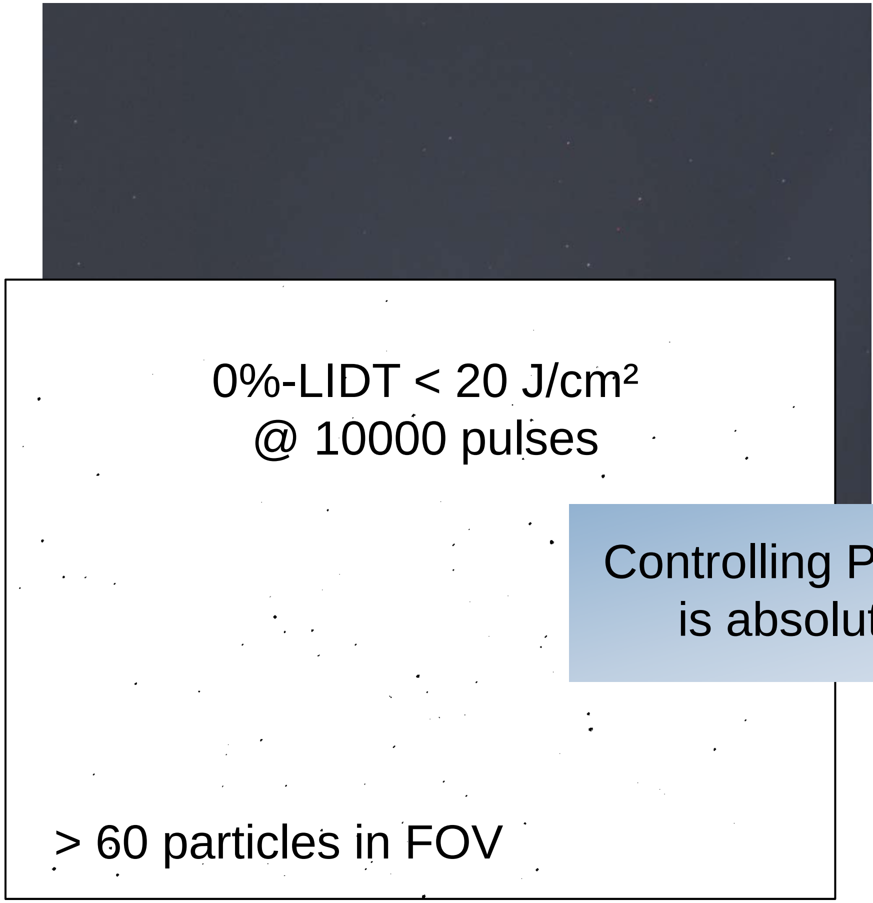
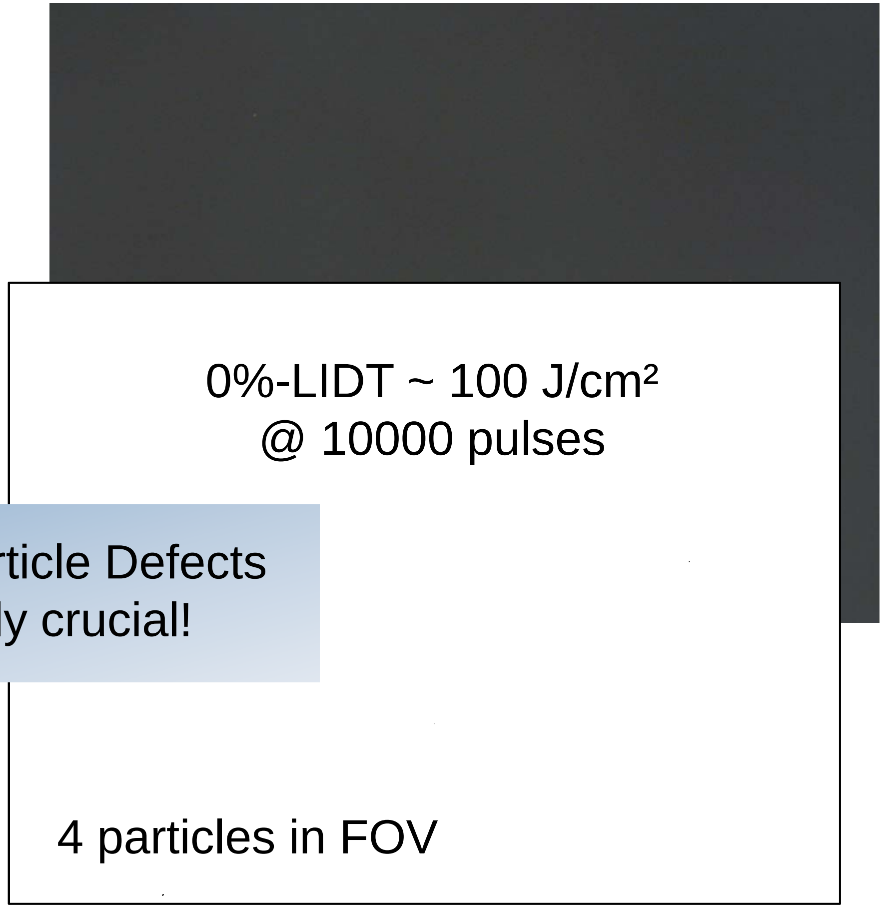
Laser-induced Damage Threshold S-on-1 measurement according to ISO 21254-2

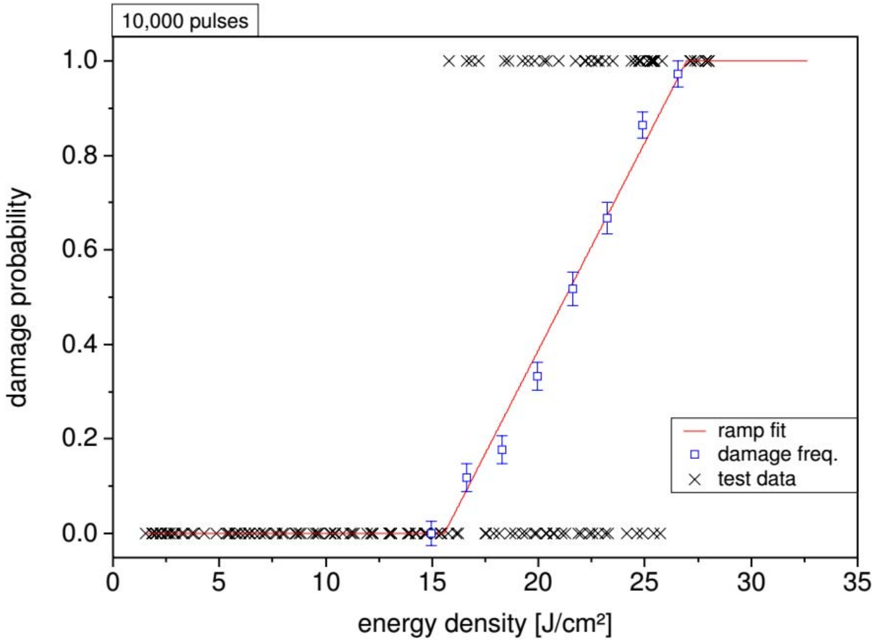
The Role of Particle Defects





Controlling Particle Defects
is absolutely crucial!

Laser-Induced Damage at 355nm



Number of pulses	First observed damage [J/cm²]
4	17.23
10	15.81
23	15.81
54	15.81
130	15.81
310	15.81
740	15.81
1,800	15.81
4,200	15.81
10,000	15.81

Wavelength	355 nm
Operating mode	pulsed @ 100 Hz
Pulse duration	5 ns (FWHM)

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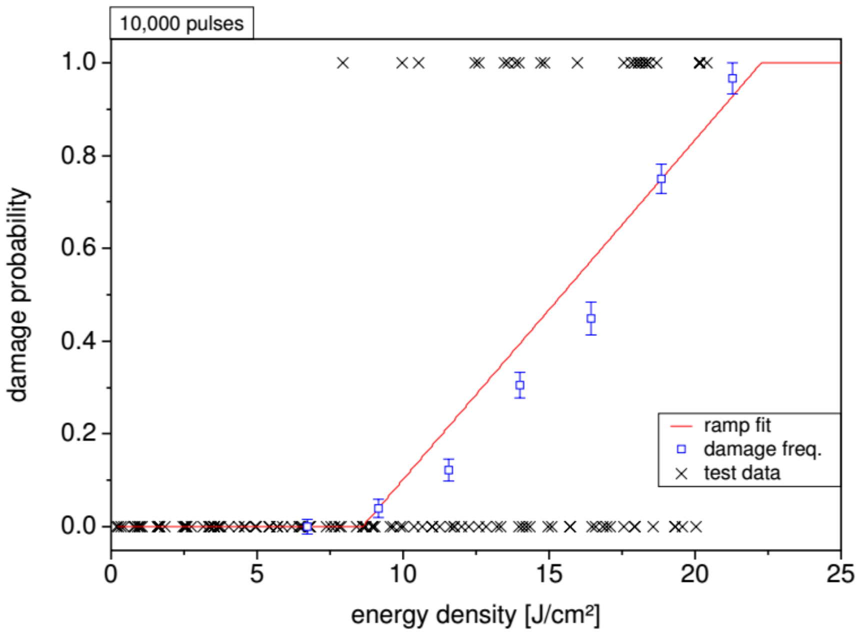
Laser-induced Damage Threshold S-on-1 measurement according to ISO 21254-2

Laser-Induced Damage at 266nm



Number of pulses	First observed damage [J/cm²]
30	17.84
57	13.50
110	13.50
210	13.50
400	13.50
760	13.50
1,400	12.50
2,800	9.99
5,200	7.94
10,000	7.94

Wavelength	266 nm
Operating mode	pulsed @ 100 Hz
Pulse duration	4,5 ns (FWHM)

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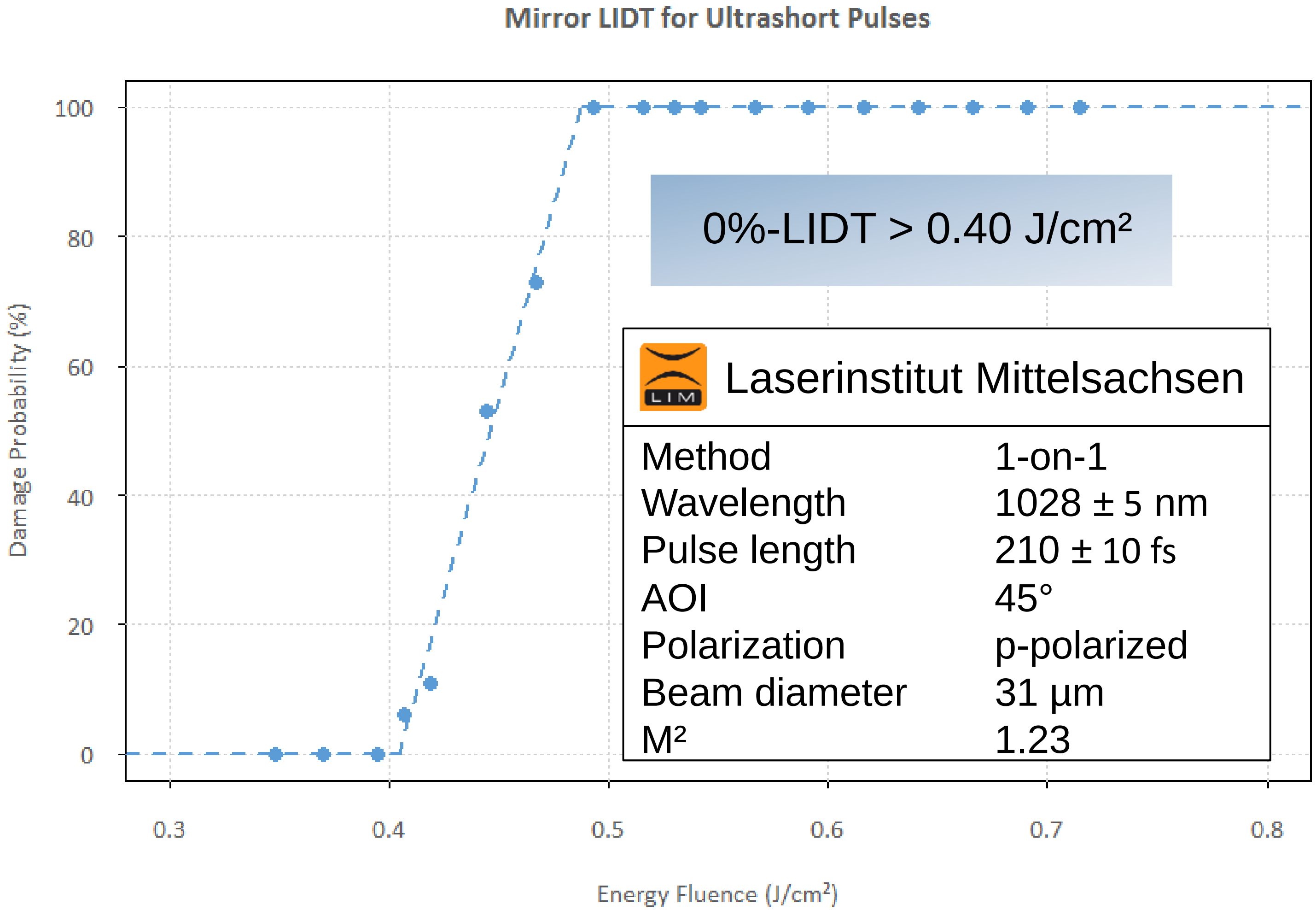
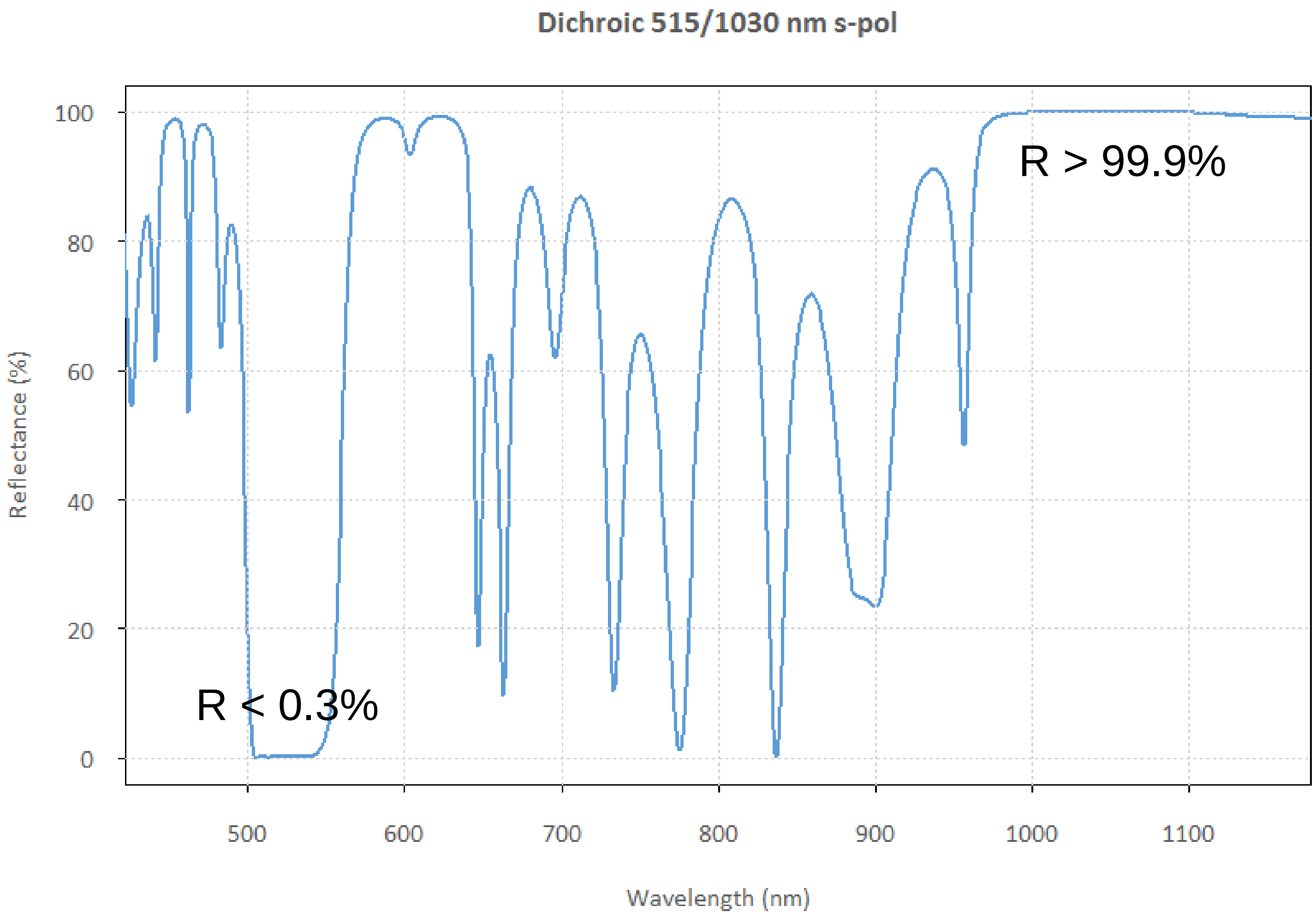
Laser-induced Damage Threshold S-on-1 measurement according to ISO 21254-2

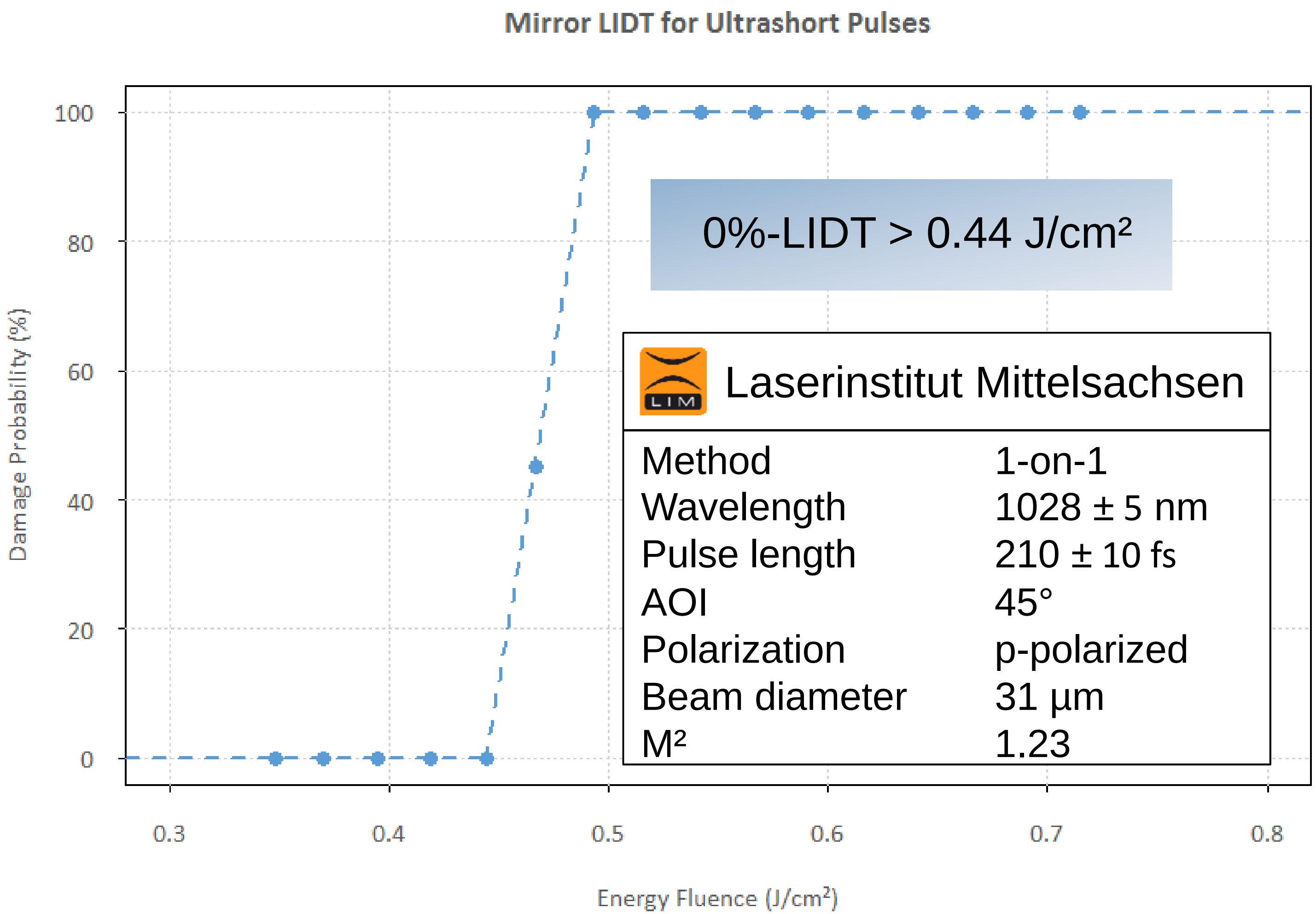
LIDT for Ultrafast Laser Applications



LIDT for Ultrafast Laser Applications



LIDT for Ultrafast Laser Applications (Dichroic)



Summary

Plasma-Assisted Reactive Magnetron Sputtering,
using RF Magnetron Technology and Ceramic Targets,
in combination with Optical Broadband Monitoring,
can provide High Performance Laser Mirrors
with Complex Spectral Functions, Low Loss,
and Superior Resistance to Laser-Induced Damage.

Thank you!