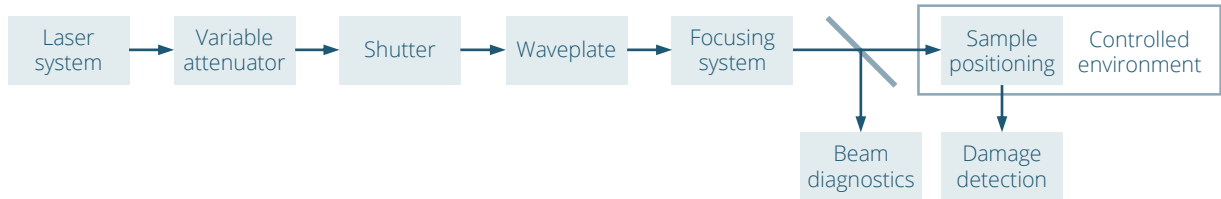


TEST EQUIPMENT

Test setup



Laser and its parameters

Type	Q-switched, seeded Nd:YAG
Manufacturer	InnoLas Laser II
Model	SpitLight Hybrid
Central wavelength	355.0 nm
Angle of incidence	55.8 deg
Polarization state	Linear S
Pulse repetition frequency	100 Hz
Spatial beam profile in target plane	TEM00
Beam diameter in target plane (1/e ²)	(233.9 ± 2.4) μm
Longitudinal pulse profile	Single longitudinal mode
Pulse duration (FWHM)	(5.6 ± 0.3) ns
Pulse to pulse energy stability (SD)	1.1 %

Energy/power meter

Manufacturer	Ophir
Model	PE50-DIF-C
Calibration due date	2021-06-01

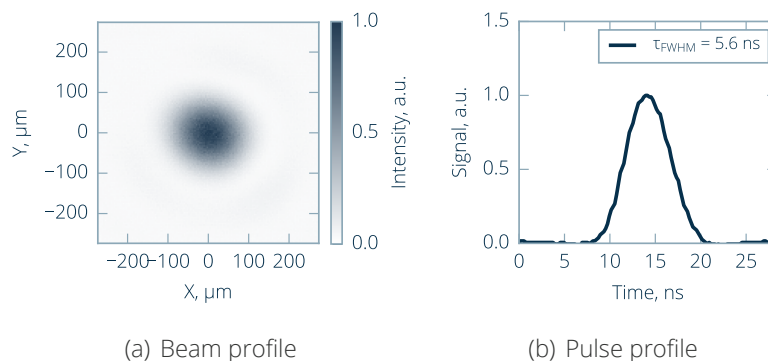


Figure 1. Laser parameters used for measurements.

TEST SPECIFICATION

Definitions and test description

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. ¹

LID of the sample is investigated by performing a standardized S-on-1 test procedure.² LIDT value is determined by fitting experimental damage probability data with a model derived for a Poisson damage process assuming degenerate defect ensemble. ³

Test sites

Number of sites	151
Arrangement of sites	Hexagonal
Minimum distance between sites	750 µm
Maximum pulses per site	1000

Analysis information

Online detection	Scattered light diode
Offline detection	Nomarski microscope
Software version	dd33b07 - 9539b8e

Test environment

Environment	Air
Cleanroom class (ISO 14644-1)	ISO7
Pressure	1 bar
Temperature	21.3 - 21.6 C
Humidity	25.2 - 25.8 %

Sample preparation

Storage before test	Normal laboratory conditions
Dust blow-off	None
Cleaning	None

¹ISO 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)

²ISO 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)

³J. Porteus and S. Seitel, Absolute onset of optical surface damage using distributed defect ensembles, Applied Optics, 23(21), 3796-3805 (1984)

LIDT TEST RESULTS

LIDT VALUE

10 ³ -on-1	3.34 ^{+0.71} / _{-1.57} J/cm ²	3.72 ^{+0.79} / _{-1.75} J/cm ² (scaled to 7.0 ns)
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CHARACTERISTIC DAMAGE CURVE

Table 1: Estimated LIDTs from fitting model for sample M0050994.

Test mode	Threshold (Offline detection - microscopy)	Threshold (Offline detection - microscopy) scaled to 7.0 ns	Threshold (Online detection - scattering)	Threshold (Online detection - scattering) scaled to 7.0 ns
10-on-1	-	-	4.24 ^{+0.67} / _{-1.70} J/cm ²	4.73 ^{+0.74} / _{-1.90} J/cm ²
10 ² -on-1	-	-	4.02 ^{+0.68} / _{-1.78} J/cm ²	4.48 ^{+0.76} / _{-1.98} J/cm ²
10 ³ -on-1	3.34 ^{+0.71} / _{-1.57} J/cm ²	3.72 ^{+0.79} / _{-1.75} J/cm ²	3.34 ^{+0.71} / _{-1.57} J/cm ²	3.72 ^{+0.79} / _{-1.75} J/cm ²

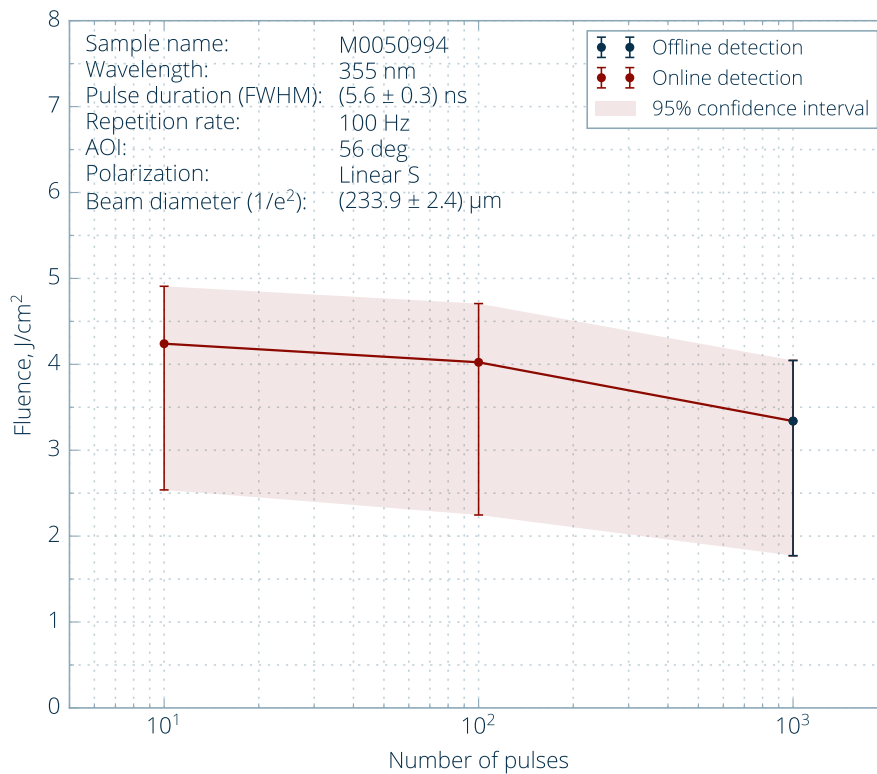
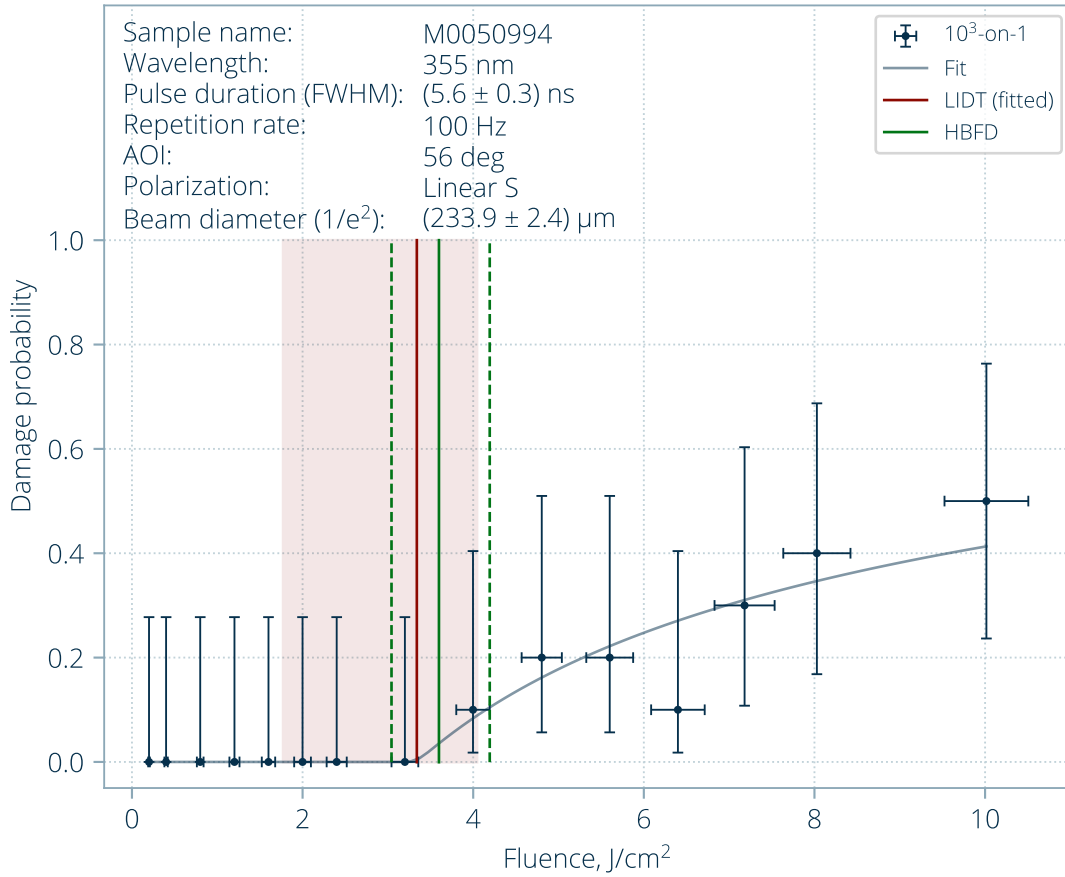


Figure 2. Characteristic damage curve.

DAMAGE PROBABILITY (OFFLINE DETECTION)



(a) 10³-on-1

Figure 3. Damage probability plot. ⁴

⁴Read Technical Note 1

TYPICAL DAMAGE MORPHOLOGY (OFFLINE DETECTION)

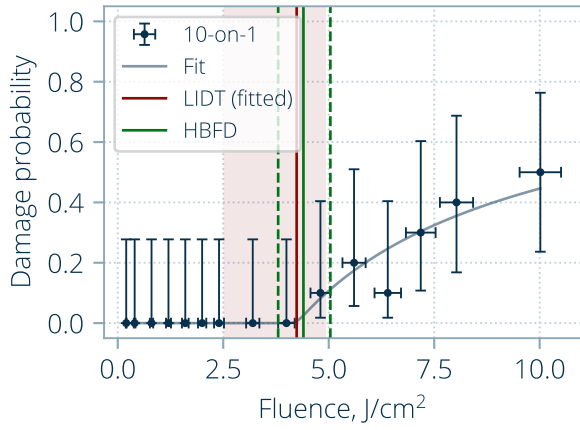


Figure 4. Typical damage morphology: fluence 3.96 J/cm^2 , damage after 176 pulse(s).

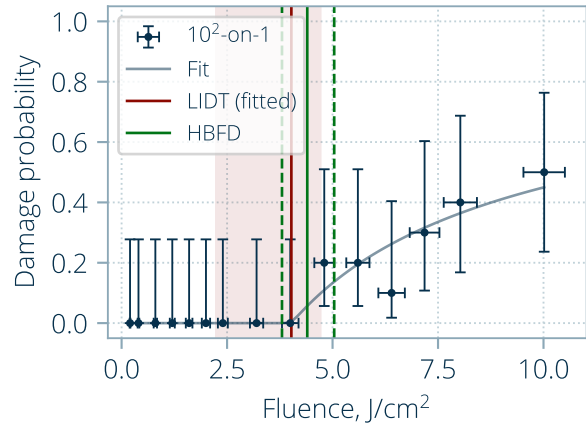


Figure 5. Typical damage morphology: fluence 5.56 J/cm^2 , damage after 69 pulse(s).

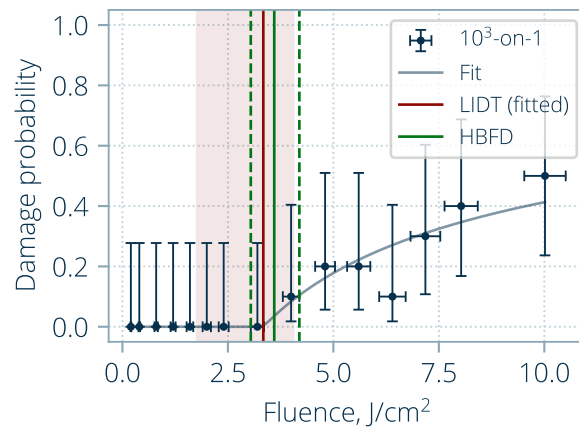
DAMAGE PROBABILITY (ONLINE DETECTION)



(a) 10-on-1



(b) 10²-on-1



(c) 10³-on-1

Figure 6. Damage probability plots. ⁵

HIGHEST THRESHOLD BEFORE FIRST DAMAGE CURVE (NOT ISO STANDARD)

Table 2: Estimated thresholds as HBFD for sample M0050994.

Test mode	Threshold (Offline detection - microscopy)	Threshold (Offline detection - microscopy) scaled to 7.0 ns	Threshold (Online detection - scattering)	Threshold (Online detection - scattering) scaled to 7.0 ns
10-on-1	-	-	4.40 $^{+0.64}_{-0.60}$ J/cm ²	4.91 $^{+0.71}_{-0.67}$ J/cm ²
10 ² -on-1	-	-	4.40 $^{+0.64}_{-0.60}$ J/cm ²	4.91 $^{+0.71}_{-0.67}$ J/cm ²
10 ³ -on-1	3.60 $^{+0.60}_{-0.56}$ J/cm ²	4.01 $^{+0.66}_{-0.62}$ J/cm ²	3.60 $^{+0.60}_{-0.56}$ J/cm ²	4.01 $^{+0.66}_{-0.62}$ J/cm ²

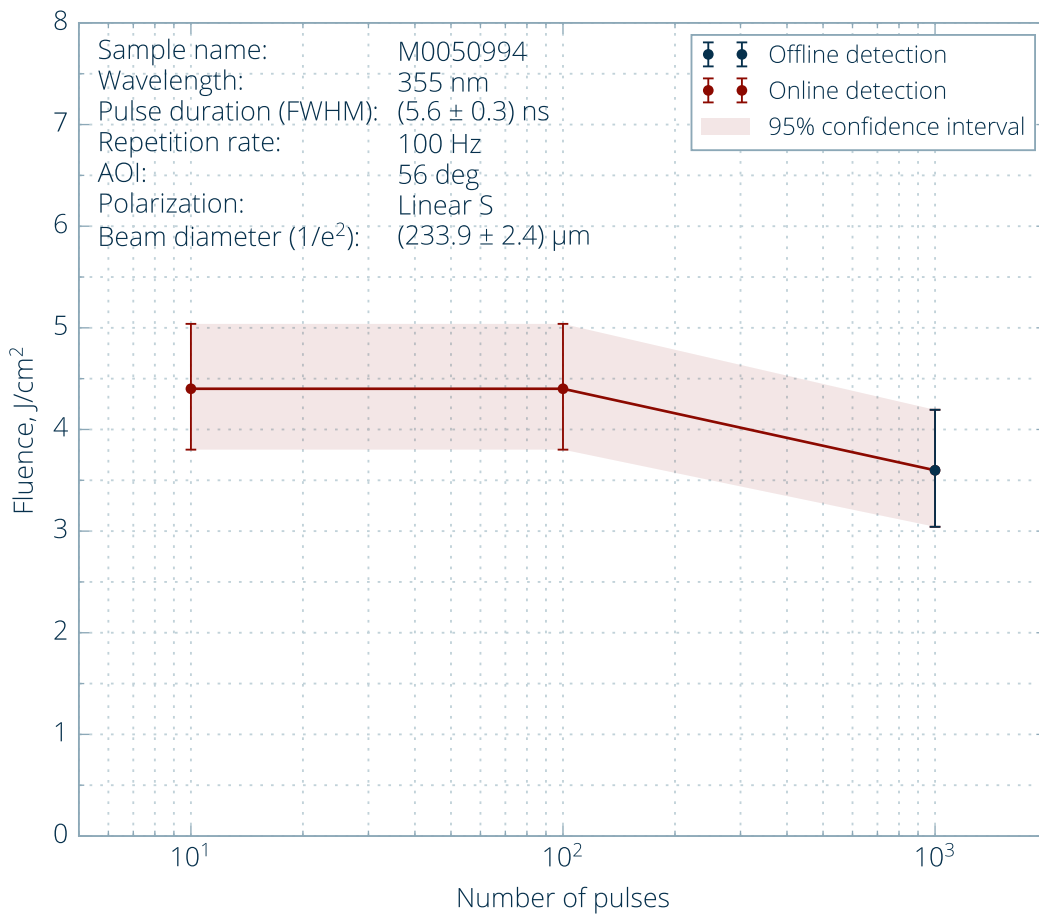


Figure 7. Highest threshold before first damage curve. ⁶

⁶Read Technical Note 1

TECHNICAL NOTES

TECHNICAL NOTE 1: Non standard HBFD threshold estimation

HBFD (Highest Before First Damage) values represent threshold values determined by taking the average of the highest fluence value before which no damage was observed and the lowest fluence value at which damage was first observed. This value is not ISO standard threshold and it should be considered as complimentary information. It was included in the report because error of the highest pulse class LIDT value exceeded 30%.

TECHNICAL NOTE 2: Oblique incidence

According to the ISO 21254-2:2011 standard, for spatial beam profiling perpendicular to the direction of beam propagation and angles of incidence differing from 0 degrees, the cosine of the angle of incidence is included in the calculation of the effective area, which leads to correct evaluation of laser fluence at different angles of incidence (Figure 8).

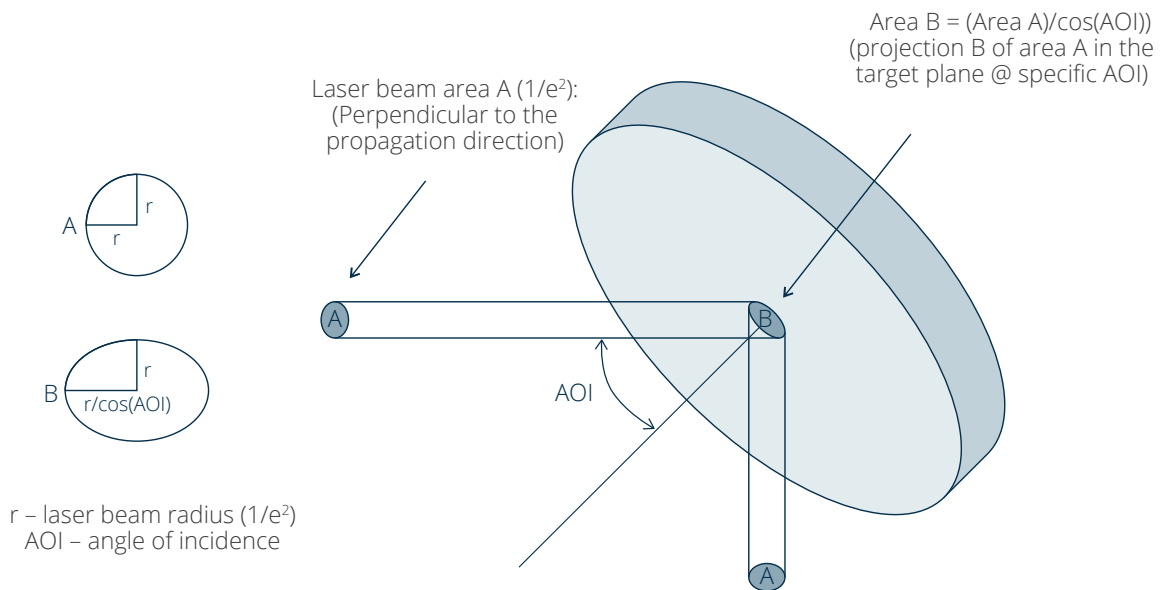


Figure 8. Oblique incidence.

TECHNICAL NOTE 3: Small test area

Due to small sample surface standardized S-on-1 test procedure results might be inaccurate. In order to increase precision, bigger sample test surface is recommended. Defect driven laser damage is probabilistic phenomena, therefore bigger sample surface could contain higher number of test sites and as a result, this could increase accuracy of LIDT estimation.