LIDARIS
LIDT Service

LASER-INDUCED DAMAGE THRESHOLD (LIDT) MEASUREMENT REPORT

S-ON-1 (ISO 21254-2) TEST PROCEDURE

SAMPLE: SO_NS_10MM

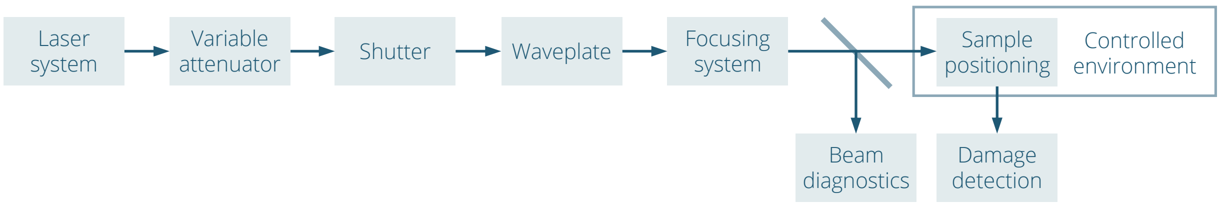
Request from	
Address	Altechna R&D Mokslininkų g. 6A, 3 aukštas LT-08412 Vilnius Lithuania
Contact person	Giedrė Šareikaitė
Purchase order	PO-0000249

Testing institute	
Address	UAB Lidaris Saulėtekio al. 10 10223 Vilnius Lithuania
Tester	Lina Vigricaite
Test date	16/03/2020
Sale order	SO1764
Test ID	E7VNVK

Specimen	
Name	SO_ns_10mm
Type	Uncoated (S1 Uncoated)
Packaging	Plastic box

TEST EQUIPMENT

Test setup

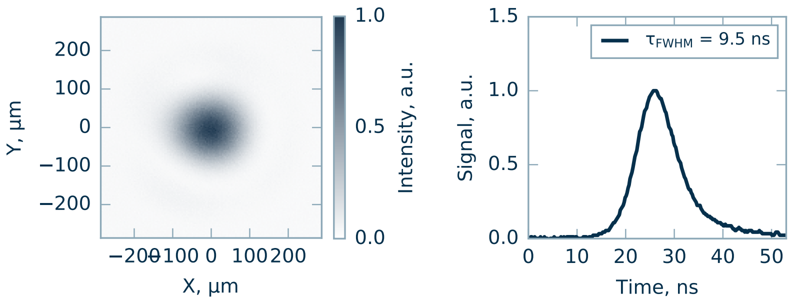


Laser and its parameters

Type	Q-switched, seeded Nd:YAG
Manufacturer	InnoLas Laser II
Model	SpitLight Hybrid
Central wavelength	1064.0 nm
Angle of incidence	0.0 deg
Polarization state	Linear
Pulse repetition frequency	100 Hz
Spatial beam profile in target plane	TEM00
Beam diameter in target plane ($1/e^2$)	(237.9 ± 4.1) μm
Longitudinal pulse profile	Single longitudinal mode
Pulse duration (FWHM)	(9.5 ± 0.3) ns
Pulse to pulse energy stability (SD)	1.2 %

Energy/power meter

Manufacturer	Ophir
Model	PE50-DIF-C
Calibration due date	2020-07-01



(a) Beam profile (b) Pulse profile

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	138
Arrangement of sites	Hexagonal
Minimum distance between sites	750 µm
Maximum pulses per site	1000

Damage detection

Online	Scattered light diode
Offline	Nomarski microscope

Test environment

Environment	Air
Cleanroom class (ISO 14644-1)	ISO7
Pressure	1 bar
Temperature	22 C
Humidity	12 %

Sample preparation

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

[1] 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)
[2] 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)
[3] J. 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	$63.4^{+9.7}_{-28.5}$ J/cm^2

CHARACTERISTIC DAMAGE CURVE

Table 1: Estimated LIDTs from fiting model for sample SO_ns_10mm.

Test mode	Threshold (Catastrophic) [4]	Threshold (Offline detection - microscopy)	Threshold (Online detection - scattering)
10-on-1	-	-	$63.4^{+9.7}_{-28.5}$ J/cm^2
10^2-on-1	-	-	$63.4^{+9.7}_{-28.5}$ J/cm^2
10^3-on-1	> $109.8^{+8.2}_{-8.2}$ J/cm^2	$63.4^{+9.7}_{-28.5}$ J/cm^2	$63.4^{+9.7}_{-28.5}$ J/cm^2

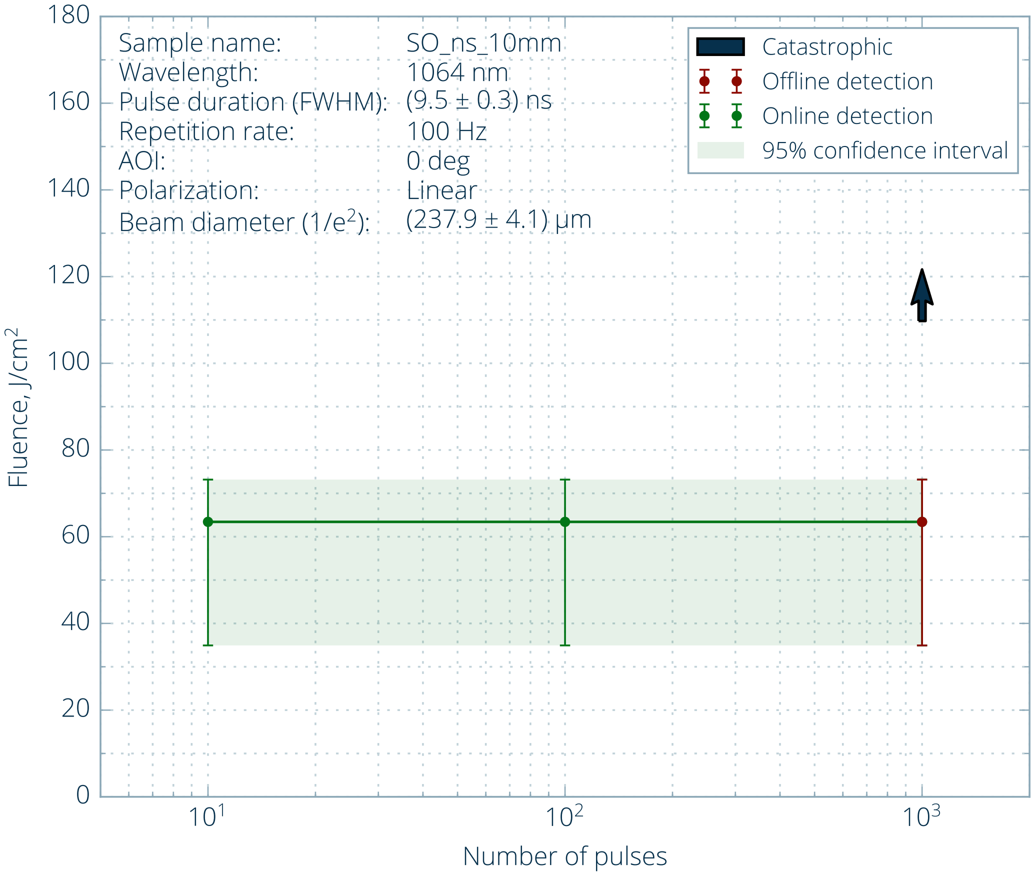
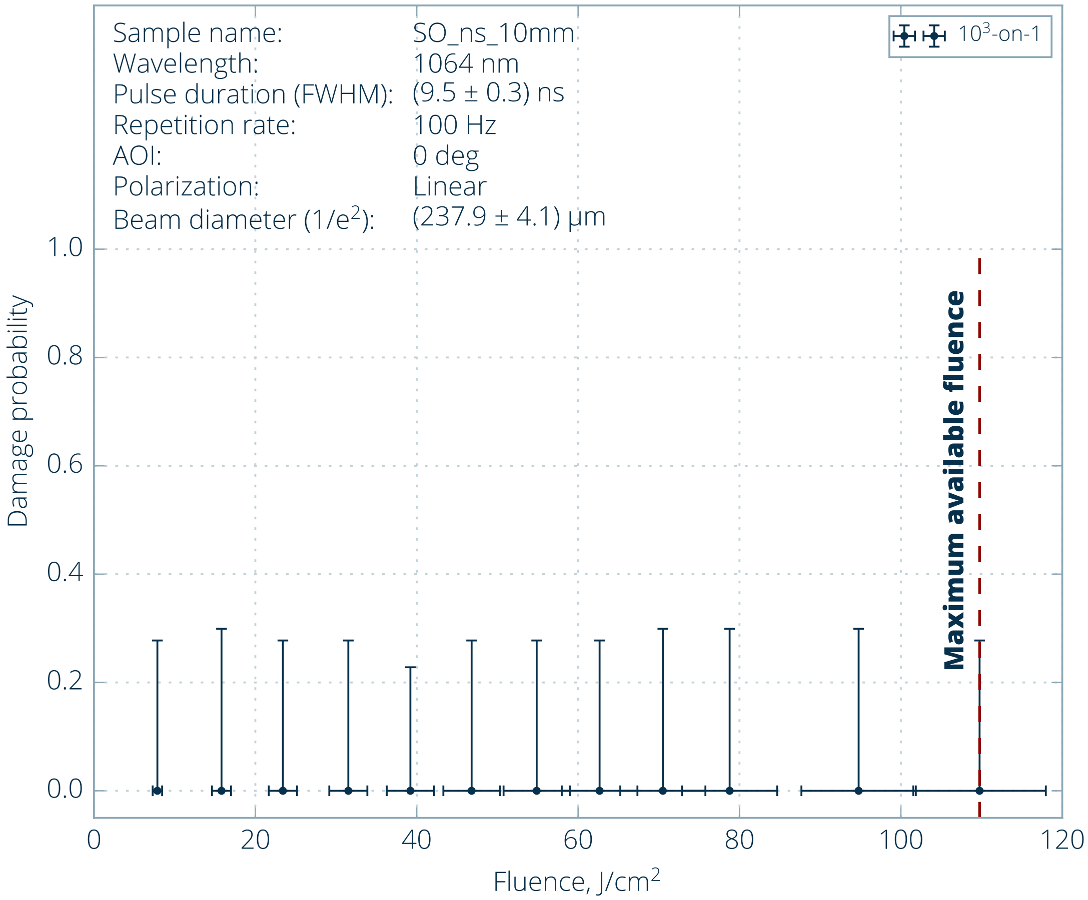


Figure 2. Characteristic damage curve.

[4] Read Technical Note 1

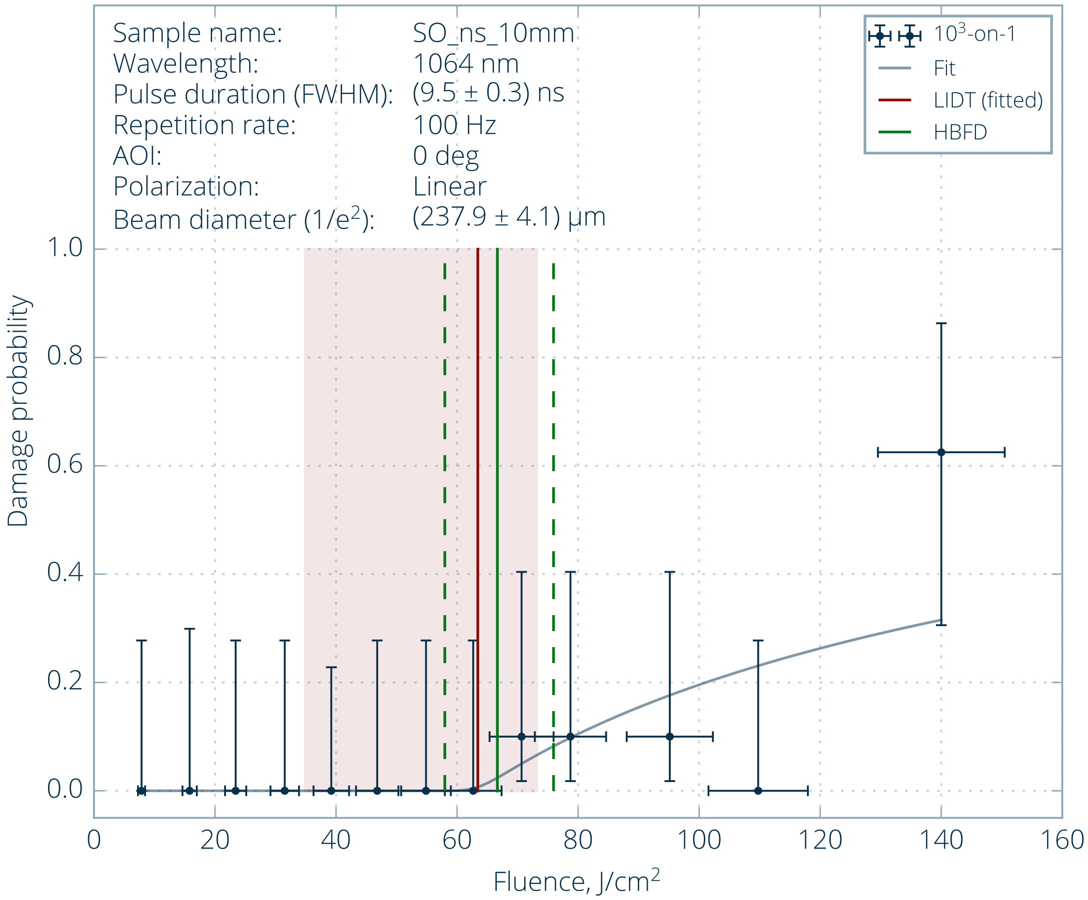
DAMAGE PROBABILITY (CATASTROPHIC)



(a) 10^3-on-1

Figure 3. Damage probability plot. [4]

DAMAGE PROBABILITY (OFFLINE DETECTION)



(a) 10^3-on-1

Figure 4. Damage probability plot. [5]

[5] Read Technical Note 2

TYPICAL DAMAGE MORPHOLOGY (OFFLINE DETECTION)

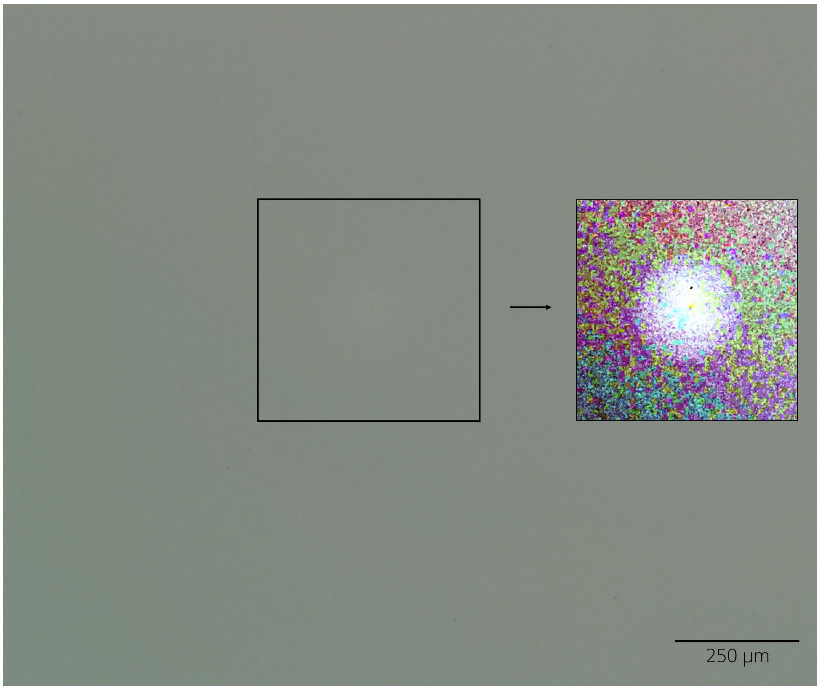


Figure 5. Typical damage morphology: fluence 72.1 J/cm^2, damage after 1 pulse(s). High contrast image.

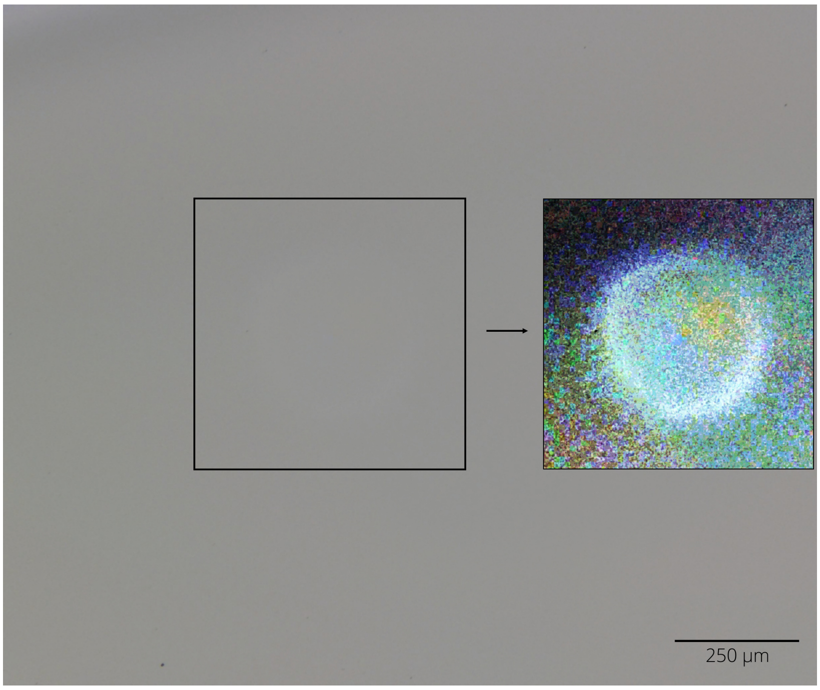
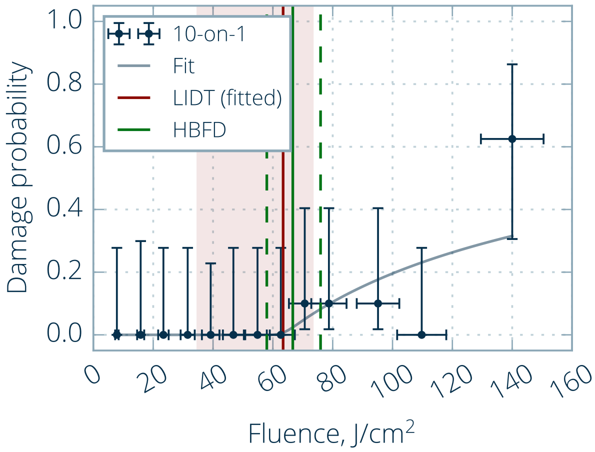
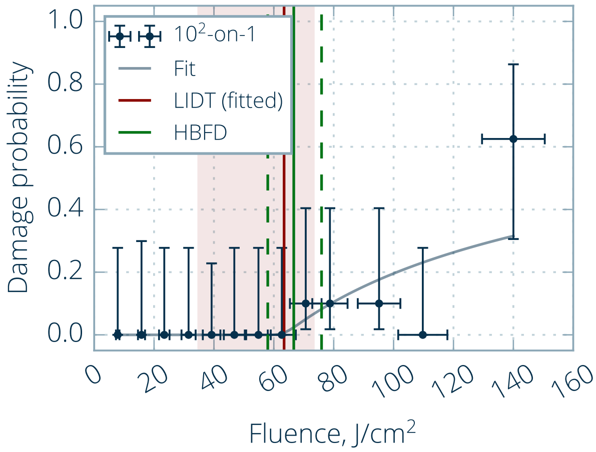


Figure 6. Typical damage morphology: fluence 140 J/cm^2, damage after 1 pulse(s). High contrast image.

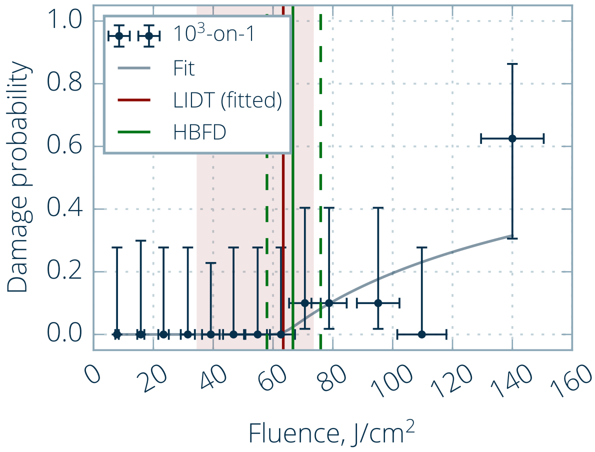
DAMAGE PROBABILITY (ONLINE DETECTION)



(a) 10-on-1



(b) 10^2-on-1



(c) 10^3-on-1

Figure 7. Damage probability plots. [6]

[6] Read Technical Note 2

HIGHEST THRESHOLD BEFORE FIRST DAMAGE CURVE (NOT ISO STANDARD)

Table 2: Estimated thresholds as HBFD for sample SO_ns_10mm.

Test mode	Threshold (Catastrophic)	Threshold (Offline detection - microscopy)	Threshold (Online detection - scattering)
10-on-1	-	-	$66.7^{+9.3}_{-8.7}$ J/cm^2
10^2-on-1	-	-	$66.7^{+9.3}_{-8.7}$ J/cm^2
10^3-on-1	-	$66.7^{+9.3}_{-8.7}$ J/cm^2	$66.7^{+9.3}_{-8.7}$ J/cm^2

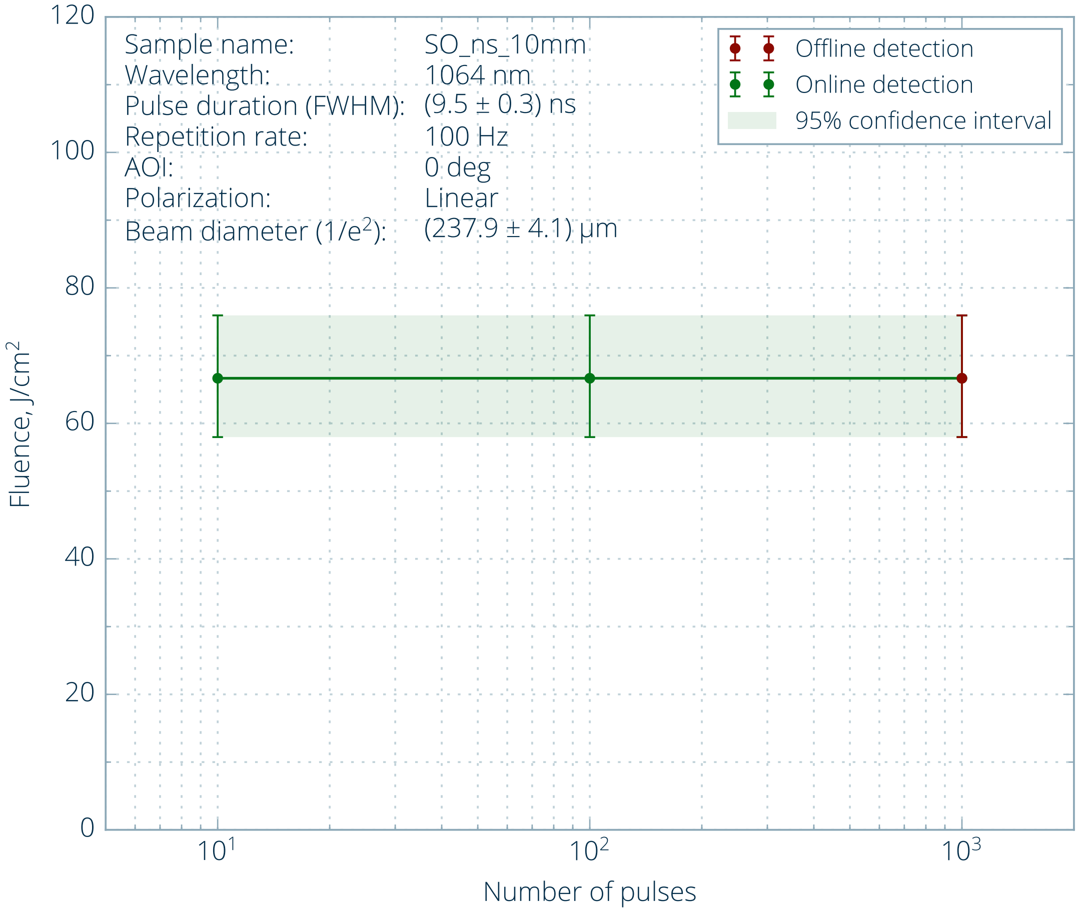


Figure 8. Highest threshold before first damage curve. [7]

[7] Read Technical Note 2

TECHNICAL NOTES

TECHNICAL NOTE 1: No damages were found

No damages were found for this type of analysis, 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 thresholds table.

TECHNICAL NOTE 2: 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.
Density of surface defects in the sample was very low. In these conditions standardized S-on-1 test procedure results are inconclusive, as using S-on-1 test procedure only small fraction of sample surface is tested. In this particular case rare defect density damage probabilities are always low, thus there is high risk that surface defects are not exposed with the laser radiation. Accordingly, fitting low damage probabilities with a model derived for a Poisson damage process assuming degenerate defect ensemble leads to inaccurate estimation of LIDT and large error bars.
To sum up, standardized S-on-1 test procedure results inconclusive LIDT. Raster scan procedure is recommended for proper LIDT determination in such cases (please contact us for more details).

TECHNICAL NOTE 3: Bulk damages were not found

After the test bulk damages were not found

TECHNICAL NOTE 4: Back surface damages were not found

After the test back surface damages were not found

TECHNICAL NOTE 5: Beam was focused inside the sample

Beam was focused inside the sample. Fluence is estimated in the beam focal spot.