LASER-INDUCED DAMAGE THRESHOLD (LIDT) MEASUREMENT REPORT

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

SAMPLE: SU012564 M0073803LOT0057528AR

Request from	
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Purchase order	PU0015930-AVA

Testing institute	
Address	UAB Lidaris Saulėtekio al. 10 10223 Vilnius Lithuania
Tester	Egidijus Pupka
Test date	2020-01-14
Sale order	SO1611
Test ID	EQ61ZE

Specimen	
Name	SU012564 M0073803LOT0057528AR
Type	AR Coating (Coating: AR<0.25% @1898-1918 + AR<0,65% @ 2075-2105)
Packaging	Wrapped in paper

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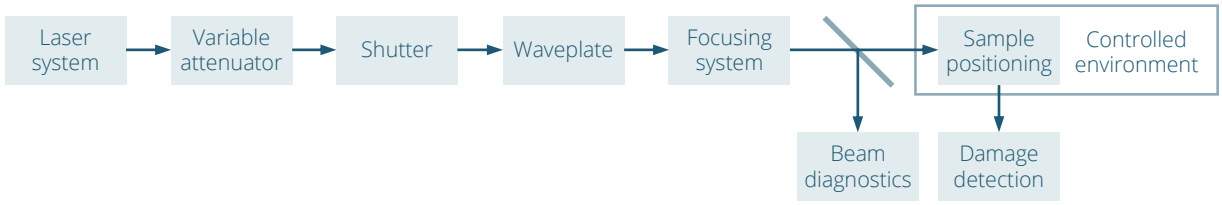
TEST EQUIPMENT

Test setup

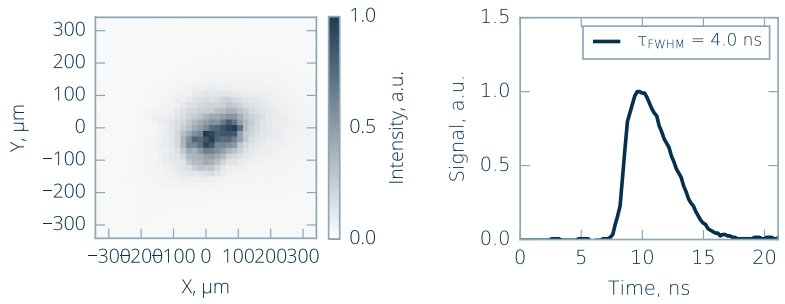


Laser and its parameters

Type	Q-switched, seeded Nd:YAG
Manufacturer	InnoLas Laser II
Model	SpitLight Hybrid with OPO
Central wavelength	2090.0 nm
Angle of incidence	0.0 deg
Polarization state	Linear
Pulse repetition frequency	100 Hz
Spatial beam profile in target plane	Near Gaussian
Beam diameter in target plane ($1/e^2$)	(181.9 ± 5.9) µm
Longitudinal pulse profile	Single longitudinal mode
Pulse duration (FWHM)	(4.0 ± 0.3) ns
Pulse to pulse energy stability (SD)	3.4 %

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.

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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	209
Arrangement of sites	Hexagonal
Minimum distance between sites	600 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	23 C
Humidity	26 %

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	11.0 $^{+4.1}_{-8.2}$ J/cm^2	17.3 $^{+6.4}_{-12.9}$ J/cm^2 (scaled to 10 ns)

CHARACTERISTIC DAMAGE CURVE

Table 1: Estimated LIDTs from fiting model for sample SU012564 M0073803LOT0057528AR.

Test mode	Threshold (Offline detection - microscopy)	Threshold (Offline detection - microscopy) scaled to 10 ns	Threshold (Online detection - scattering)	Threshold (Online detection - scattering) scaled to 10 ns
10-on-1	-	-	13.0 $^{+7.3}_{-12.8}$ J/cm^2	20.4 $^{+11.4}_{-20.1}$ J/cm^2
10^2-on-1	-	-	13.0 $^{+7.3}_{-12.8}$ J/cm^2	20.4 $^{+11.4}_{-20.1}$ J/cm^2
10^3-on-1	11.0 $^{+4.1}_{-8.2}$ J/cm^2	17.3 $^{+6.4}_{-12.9}$ J/cm^2	13.0 $^{+7.3}_{-12.8}$ J/cm^2	20.4 $^{+11.4}_{-20.1}$ J/cm^2

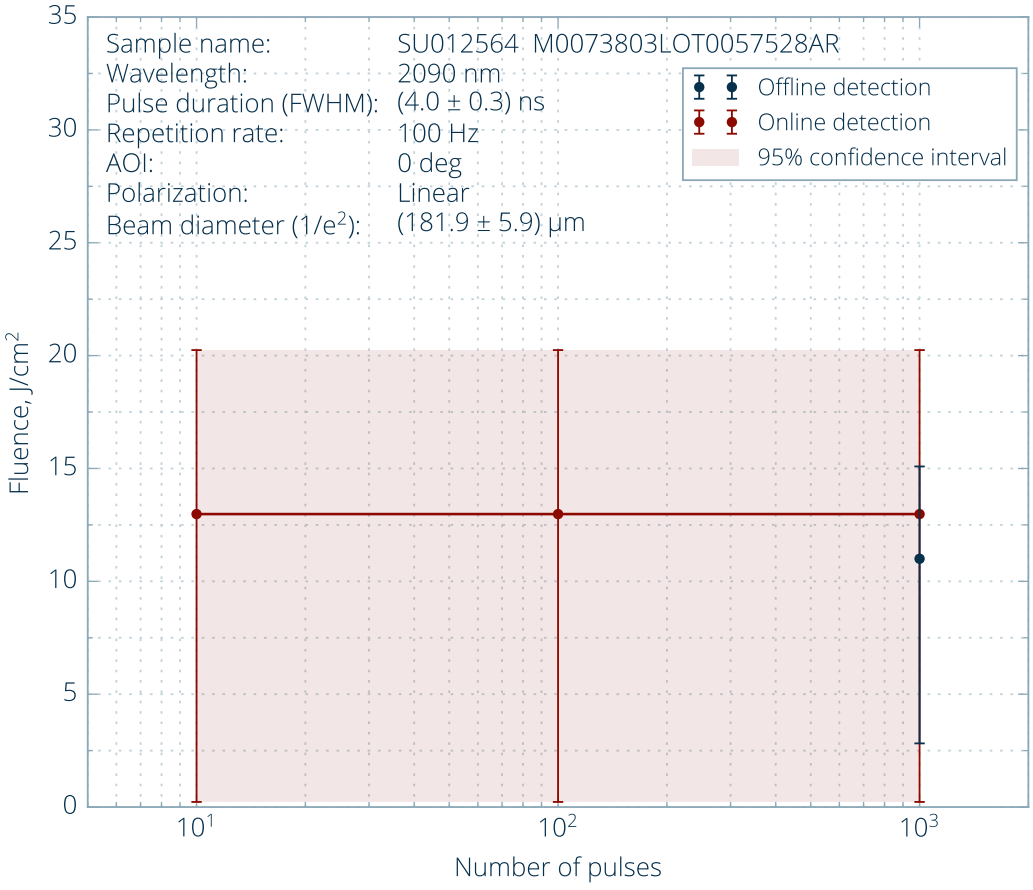
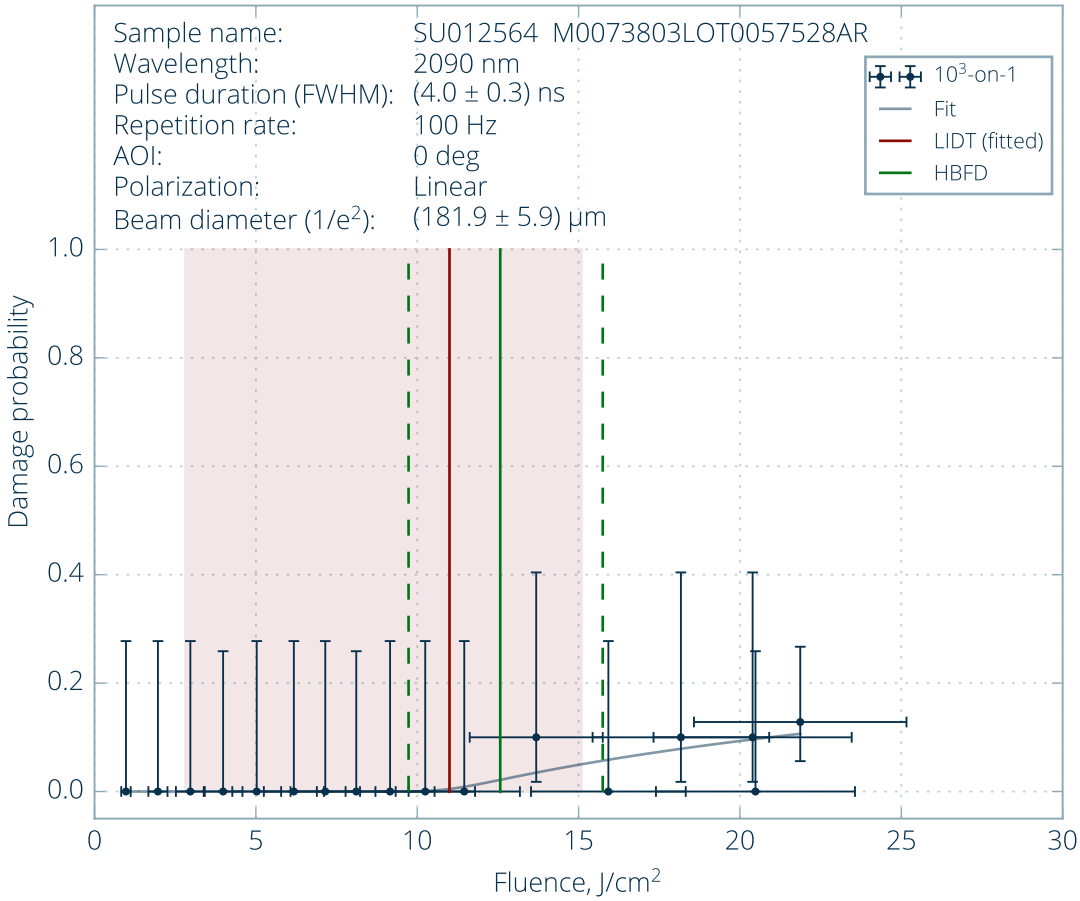


Figure 2. Characteristic damage curve.

DAMAGE PROBABILITY (OFFLINE DETECTION)



(a) 10^3-on-1

Figure 3. Damage probability plot. [4]

[4] Read Technical Note 1

TYPICAL DAMAGE MORPHOLOGY (OFFLINE DETECTION)

Figure 4. Typical damage morphology: fluence 13.7 J/cm^2, damage after 1000 pulse(s).

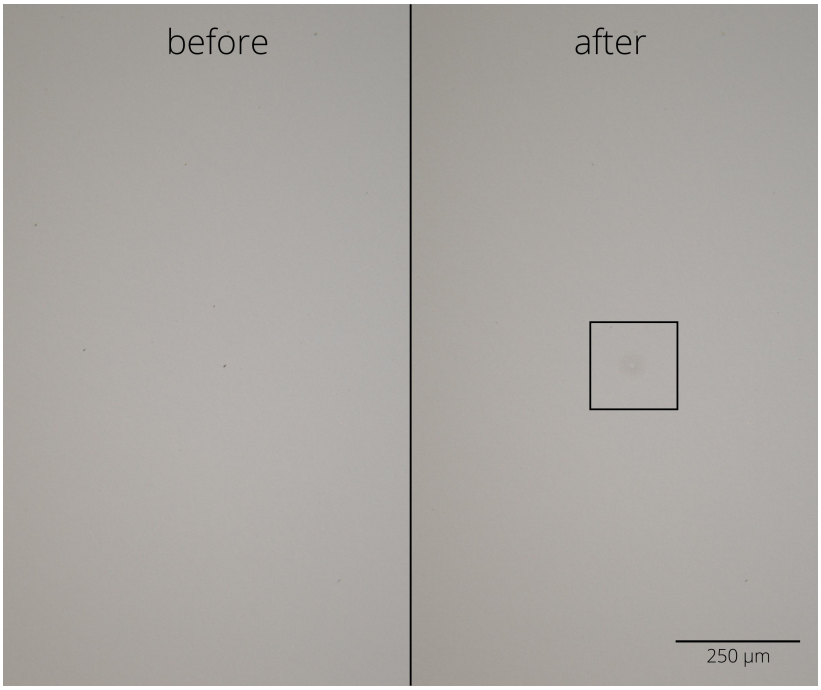
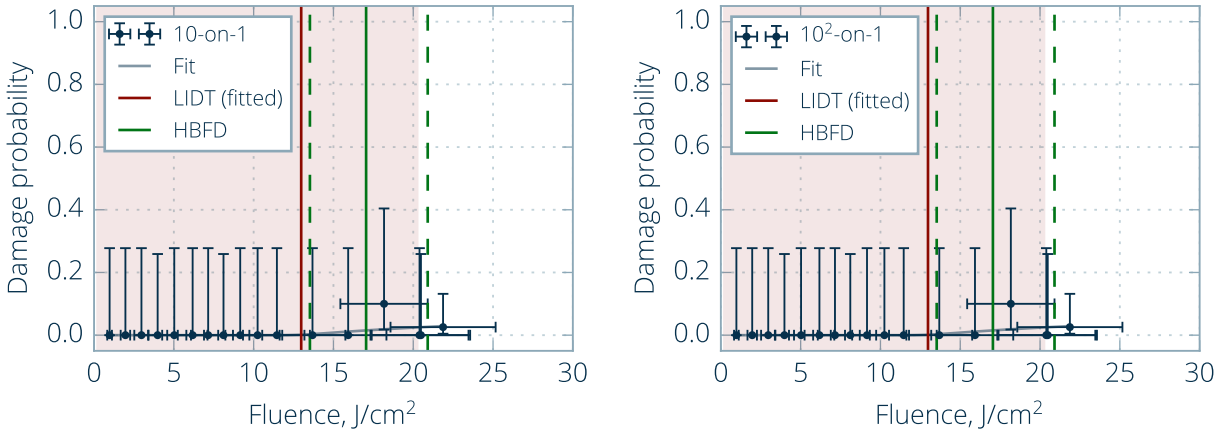


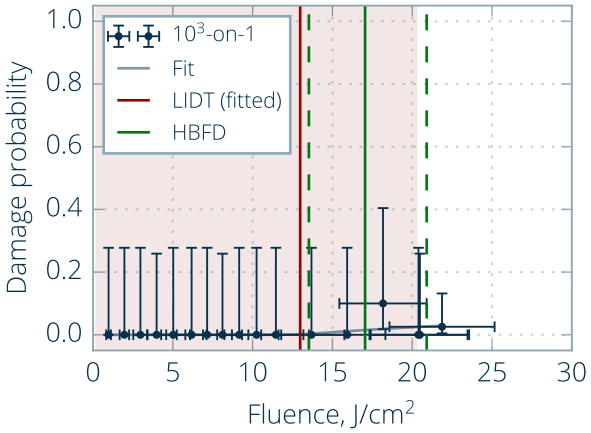
Figure 5. Typical damage morphology: fluence 21.9 J/cm^2, damage after 1000 pulse(s).

DAMAGE PROBABILITY (ONLINE DETECTION)



(a) 10-on-1

(b) 10^2-on-1



(c) 10^3-on-1

Figure 6. Damage probability plots. [5]

[5] Read Technical Note 1

HIGHEST THRESHOLD BEFORE FIRST DAMAGE CURVE (NOT ISO STANDARD)

Table 2: Estimated thresholds as HBFD for sample SU012564 M0073803LOT0057528AR.

Test mode	Threshold (Offline detection - microscopy)	Threshold (Offline detection - microscopy) scaled to 10 ns	Threshold (Online detection - scattering)	Threshold (Online detection - scattering) scaled to 10 ns
10-on-1	-	-	$17.0\ ^{+3.9}_{-3.5}$ J/cm^2	$26.8\ ^{+6.1}_{-5.5}$ J/cm^2
10^2-on-1	-	-	$17.0\ ^{+3.9}_{-3.5}$ J/cm^2	$26.8\ ^{+6.1}_{-5.5}$ J/cm^2
10^3-on-1	$12.6\ ^{+3.2}_{-2.8}$ J/cm^2	$19.8\ ^{+5.0}_{-4.5}$ J/cm^2	$17.0\ ^{+3.9}_{-3.5}$ J/cm^2	$26.8\ ^{+6.1}_{-5.5}$ J/cm^2

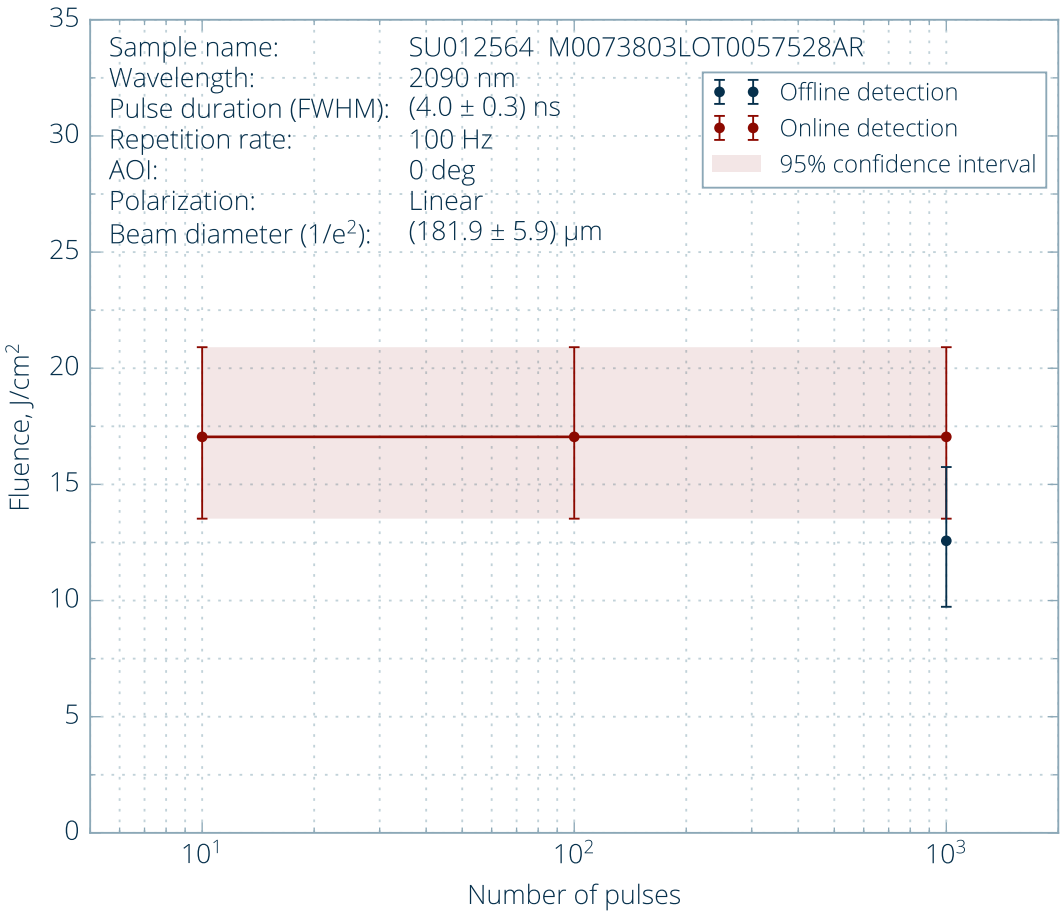


Figure 7. Highest threshold before first damage curve. [6]

[6] Read 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.
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).