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REFINING LIDT EVALUATION THROUGH MONTE CARLO SIMULATIONS: A PATH TO ISO EXCELLENCE

Martynas Keršys[1], Andrius Melninkaitis[1,2]

[1]Vilnius University, Physics Faculty, Laser Research Center
[2]UAB Lidaris
martynas.kersys@ff.stud.vu.lt

The assessment of Laser-Induced Damage Threshold (LIDT) plays a pivotal role in ensuring the safety and reliability of laser systems across various scientific and industrial applications. As laser technology is constantly evolving to new irradiation regimes, there is a demand for higher quality optical components, as is to evaluate their damage threshold more accurately and reliably. As a result, there arises a need to revise the current ISO standard for LIDT testing on periodic basis [1]. But to make LIDT standardization efforts more successful and adoptable, there is a need for an easy way to evaluate these methods and show their accuracy under real and different conditions.

This research endeavors to address these challenges by exploring and implementing advanced testing techniques based on Monte Carlo simulations to numerically test and compare different testing approaches. The main goal of our research was to review the accuracy of current ISO standard techniques for LIDT testing ISO 21254:2011using numerical methods as well as prepare recommendations for the upcoming revision of this standard. For the new revision of this standard, new functional tests, namely R-on-1 and raster scan [2], are intended to be implemented.

In our research, we first compare the classical methods of evaluating the LIDT with our own empirical and experimental insight-based algorithm for 1-on-1 and S-on-1 testing using Monte Carlo simulations. We then go on to evaluate and optimize testing conditions for R-on-1 tests and raster scans, comparing them with the former methods. We do these tests by first generating a virtual sample with randomly distributed sporadic defects on XY plane and by sampling it with a virtual laser beam (Gaussian and a flat top) on our surface to detect them. We introduce a requirement for these tests to cover a certain amount of area $A_{90\%}$ (area where fluence is more than 90% of the peak fluence) to make them comparable with raster scan results.

In our initial findings, by running our simulations with the same initial condition for multiple iterations, we have discovered that by increasing the diameter of our Gaussian beam for roughly the same area irradiated, we decrease the deviation of LIDT values, proving that there is a strong correlation between LIDT test accuracy and the defect density of our surface.

[1] International Organization for Standardization. "ISO 21254-2: Lasers and laser-related equipment -- Test methods for laser-induced damage threshold -- Part 2: Threshold determination." Technical Committee: Optics and Optical Instruments, Subcommittee: Lasers and Laser-Related Equipment, International Standard, International Organization for Standardization, Genève, Switzerland, 2011.
[2] Borden, Michael R., et al. "Improved method for laser damage testing coated optics." Laser-Induced Damage in Optical Materials: 2005. Vol. 5991. SPIE, 2006.