INTERNATIONAL STANDARD

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Lasers and laser-related equipment — Test methods for laser-induced damage threshold —

Part 2: Threshold determination

Lasers et équipements associés aux lasers — Méthodes d'essai du seuil d'endommagement provoqué par laser —

Partie 2: Détermination du seuil

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 21254-2 was prepared by Technical Committee ISO/TC 172, *Optics and photonics*, Subcommittee SC 9, *Electro-optical systems*.

This first edition of ISO 21254-2:2011, together with ISO 21254-1:2011, cancels and replaces ISO 11254-1:2000 and ISO 11254-2:2001, which have been technically revised.

ISO 21254 consists of the following parts, under the general title *Lasers and laser-related equipment — Test methods for laser-induced damage threshold*:

— *Part 1: Definitions and general principles*

— *Part 2 : Threshold determination*

— *Part 3: Assurance of laser power (energy) handling capabilities*

— *Part 4: Inspection, detection and measurement* [Technical Report]

Introduction

This part of ISO 21254 specifies test methods for determining single-shot and multiple-shot laser-induced damage thresholds (LIDTs) of optical components, both coated and uncoated. The aim is to provide methods which will enable measurement results to be obtained which are consistent and can be rapidly and accurately compared between different test laboratories.

In the single-shot test, which is referred to as the 1-on-1 test in this International Standard, each unexposed site on the sample surface is subjected to only one pulse of laser radiation. Repeated laser radiation pulses can damage optical components, or otherwise cause them to deteriorate, at irradiation levels below those measured for single-shot damage. Besides reversible effects induced by thermal heating and distortion, irreversible damage due to ageing, microdamage and the generation or migration of defects is observed. The degradation of the optical quality is a function of the laser operating parameters and the optical system in which the component is located. The multiple-shot test, referred to as the S-on-1 test, is based on a protocol that uses a series of pulses with constant energy density at each unexposed test site.

In addition to an evaluation technique based on the survival curve for 1-on-1 tests, this part of ISO 21254 also describes two methods for the reduction of raw data obtained from S-on-1 damage tests: one using the characteristic damage curve and the other an extrapolation technique. The characteristic damage curve method calls for S-on-1 testing at a large number of sites on the optical surface of the specimen and generation of a set of three graphs indicating energy density values corresponding to probabilities of damage of 10 %, 50 % and 90 % for a selected number of pulses. The characteristic damage curve represents the results of a complete and extended laser-induced damage test, and it is recommended for basic investigations in newly developed or critical laser optics. The second method of S-on-1 testing, the extrapolation method, uses a considerably smaller number of test sites. This method generates a distribution diagram of the damaged and undamaged regions for the behaviour of the damage threshold as a function of the number of pulses per site. This diagram is of limited reliability but may be employed for the quality control of optical laser components which have already been qualified by a complete damage test or as part of the preparation for extended damage testing.

Realistic laser damage tests suitable for industrial applications require a large number of pulses (10^9 to 10^{11} pulses) and hence involve a disproportionate experimental cost. This part of ISO 21254 therefore also outlines a procedure for obtaining the S-on-1 threshold by extrapolation of the characteristic damage curve in order to estimate the real lifetime of an optical component.

NOTE It should be realized that the laser-induced damage threshold of an optical component which is subjected to repeated pulses of radiation can be affected by a variety of different degradation mechanisms, including contamination, thermal heating, migration or generation of internal defects, and structural changes. These mechanisms are influenced by the laser operating parameters, the environment and the component mounting conditions. For these reasons, it is necessary to record all the parameters and to bear in mind that the damage behaviour might differ in tests carried out in different operating conditions.

The test procedures described in this part of ISO 21254 are applicable to all combinations of laser wavelengths and pulse lengths. However, comparison of laser damage threshold data can be misleading unless the measurements have been carried out at the same wavelength, using the same pulse length and beam diameter. Definitions and the general principles of laser-induced damage threshold measurements are given in ISO 21254-1.

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WARNING — The extrapolation of damage data can lead to an overestimation of the laser-induced damage threshold. In the case of toxic materials (e.g. ZnSe, GaAs, CdTe, ThF_4, chalcogenides, Be, Cr, Ni), this can lead to serious health hazards. See ISO 21254-1:2011, Annex A, for further comments.

1 Scope

This part of ISO 21254 describes 1-on-1 and S-on-1 tests for the determination of the laser-induced damage threshold of optical laser components. It is applicable to all types of laser and all operating conditions.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 11145, *Optics and photonics — Lasers and laser-related equipment — Vocabulary and symbols*

ISO 21254-1:2011, *Lasers and laser-related equipment — Test methods for laser-induced damage threshold — Part 1: Definitions and general principles*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11145 and ISO 21254-1 apply.

4 Test methods

4.1 General

The general principles of laser-induced damage threshold measurements, and the apparatus and sampling techniques used, are described in ISO 21254-1.

4.2 1-on-1 test method

4.2.1 General

In the 1-on-1 test, each unexposed site on the surface of the sample is exposed to a single laser pulse with defined beam parameters. From the experimental data, a plot depicting the probability of damage as a function of the energy density or power density is constructed.