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Optics and photonics — Lasers and laser-related equipment — Laser-induced molecular contamination testing

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National foreword

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ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

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Foreword

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

Introduction

Laser technique is becoming increasingly important for space applications. Complex laser systems are used both for Earth observation and for planetary exploration. For long-term operations, optical components have to satisfy stringent requirements concerning precision and reliability. Before being used in space, all optical components have to be tested extensively. For standardized determination of laser damage threshold, ISO 21254 (all parts) should be applied. For characterization of optics for space applications, corresponding tests should be performed under vacuum conditions. In addition to laser damage issues, laser-induced molecular contamination (LIMC) should be taken into account. LIMC denotes the interaction of laser radiation, especially in case of high fluences and short wavelengths with volatile molecules and the resulting formation of deposits on optical components. LIMC proved to be particularly critical, if the laser system is operated under vacuum conditions and could considerably reduce the functionality of the whole laser system. Molecular contamination is mainly caused by organic materials and silicones, e.g. glues, adhesives, insulating material or circuit boards due to stronger outgassing rates compared to inorganic materials. The outgassing can be reduced but not totally prevented by selection of suitable materials and preconditioning, e.g. bake-out at elevated temperature well above the planned operating temperature. The outgassing behaviour of materials is generally characterized by these parameters: collected volatile condensable material (CVCM), total mass loss (TML), recovered mass loss (RML), volatile condensable material (VCM) and water vapour regained (WVR). Definitions and corresponding measuring specifications for these quantities can be found in ECSS-Standard Q-ST-70-02C, ASTM-E595-07 and ASTM-E1559.

This document outlines the test procedure for investigations of laser-induced molecular contamination in order to compare the growth of laser-induced depositions on optical surfaces for different molecular contamination materials.

TECHNICAL REPORT **ISO/TR 20811:2017(E)**

Optics and photonics — Lasers and laser-related equipment — Laser-induced molecular contamination testing

1 Scope

This document describes the setup, test procedure and analysis of measured data for investigation of laser-induced molecular contamination (LIMC) for space and vacuum applications.

LIMC is the formation of depositions on optical surfaces due to interaction of intense light radiation with outgassing molecules especially from organic materials. It is a phenomenon of molecular contamination and it is distinguished from particle contamination, which can occur during manufacturing, assembly, integration or test of the optical components.

Formation of laser-induced depositions can lead to deterioration of the performance of an optical system. Phase distortion, scattering and absorption can be increased by LIMC. LIMC is of particular relevance, if a laser system is operated in vacuum at short wavelength and short pulse duration. In such a case, even small partial pressure of contamination material in the range of 10^{-5} hPa could have strong negative impact on optical performance. It was also shown that the laser-induced damage threshold could be reduced by a factor of 10 and more if laser-induced depositions are involved.

Laser-induced molecular contamination and laser-induced damage are both phenomena, for which the interaction of laser radiation with optical surfaces plays a major role, in case of LIMC with additional molecular contamination. Therefore, this document is treated in relation to ISO 21254 (all parts) which specifies the test methods for the determination of laser-induced damage thresholds.

This method was derived to evaluate qualitatively, whether the material under investigation causes deposits on optical surfaces in a low-pressure environment in the presence of high-energy nanosecond pulsed laser irradiation at a wavelength of 355 nm. Due to the nature of photochemical surface reactions, this result cannot be directly transferred to scenarios where the properties of the irradiation are altered (especially wavelength, repetition rate, pulse duration, etc.). Due to the non-linear growth of the laser-induced contamination and its detection methods, this technique does not provide quantitative means to evaluate the deposit and, therefore, it should be seen as a means to compare materials relatively with respect to their laser-induced contamination behaviour.

Furthermore, it is out of the scope of this method to select representative quantities of contamination materials — representative with respect to the material partial pressure present in the vicinity of the optical surface in a real laser system. This is carefully derived with other methods and is a mandatory parameter to be fixed before applying this method.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 (all parts), *Lasers and laser-related equipment — Test methods for laser-induced damage threshold*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11145 and ISO 21254 (all parts) and the following apply.

