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Optics and photonics — Interferometric measurement of optical elements and optical systems —

Part 2: Measurement and evaluation techniques

Optique et photonique — Mesurage interférométrique de composants et systèmes optiques —

Partie 2: Mesurage et techniques d'évaluation

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 172, *Optics and Photonics*, Subcommittee SC 1, *Fundamental standards*.

This second edition cancels and replaces the first edition (ISO/TR 14999-2:2005) which has been technically revised. The main changes are:

a) Figure 1 has been updated.

b) A.1 has been aligned with the notation of ISO 14999-4.

c) Updated text referring to technologies that have evolved over the last 10+ years, such as lasers and detectors.

d) Improved clarity of the overall document (many minor edits made throughout the text).

A list of all parts in the ISO 14999 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

A series of International Standards on Indications in technical drawings for the representation of optical elements and optical systems has been prepared by ISO/TC 172/SC 1, and published as ISO 10110 under the title *Optics and photonics — Preparation of drawings for optical elements and systems*. When drafting this standards series and especially its Part 5, *Surface form tolerances* and Part 14, *Wavefront deformation tolerance*, it became evident to the experts involved that additional complementary documentation was required to describe how the necessary information on the conformance of the fabricated parts with the stated tolerances can be demonstrated. Therefore, the responsible ISO Committee ISO/TC 172/SC 1 decided to prepare an ISO Technical Report on Interferometric measurement of optical wavefronts and surface form of optical elements.

When discussing the topics which had to be included into or excluded from such a Technical Report, it was envisaged that it might be the first time, where an ISO Technical Report or Standard is prepared which deals with wave-optics, i.e., in which the ray approximation of geometrical optics is no longer valid. As a consequence, fewer references than usual were available, which made the task more difficult.

Envisaging the situation, that the topic of interferometry has so far been left blank in ISO, it was the natural wish to now be as comprehensive as possible. Therefore, the committee held discussions, whether important techniques such as interference microscopy (for characterizing the micro-roughness of optical parts), shearing interferometry (e.g. for characterizing corrected optical systems), multiple beam interferometry, coherence sensing techniques or phase conjugation techniques should be included or not. Other techniques, which are related to the classical two beam interferometry, like holographic interferometry, Moiré techniques and profilometry were also mentioned as well as Fourier transform spectroscopy or the polarization techniques, which are mainly for microscopic interferometry.

In the end, the committee adopted the guideline to include what presently are common techniques used for the purpose of characterizing the quality of optical parts as described in the ISO 10110 series. The decision was made to complete a first Technical Report, and to then update it by supplementing new parts, as required.

The committee intends that this document covers the need for qualifying optical parts and complete systems regarding the wavefront error produced by them. Such errors have a distribution over the spatial frequency scale; in this document only the low- and mid-frequency parts of this error-spectrum are covered, not the very high end of the spectrum. These high-frequency errors can be measured only by microscopy, measurement of the scattered light or by non-optical probing of the surface.

A similar statement can be made regarding the wavelength range of the radiation used for testing. ISO 14999 considers test methods with visible light as the typical case. In some cases, longer wavelength infrared radiation (e.g. 10,6 µm CO_2 lasers) is used for testing rough surfaces after grinding. A variety of laser wavelengths might be used for transmitted wavefront testing of optical systems at the application wavelength (e.g. near infrared 1,55 µm or 1,06 µm, or ultraviolet 193 nm or 248 nm excimer lasers for microlithography optics). However, these are still rare cases, which are included in standards, that will not be dealt with in detail. The wavelength range outside these borders is not covered.

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Optics and photonics — Interferometric measurement of optical elements and optical systems —

Part 2: Measurement and evaluation techniques

1 Scope

This document gives fundamental explanations to interferometric measurement objects, describes hardware aspects of interferometers and evaluation methods, and gives recommendations for test reports and calibration certificates.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Measurement objects

4.1 Surfaces

4.1.1 Boundary surfaces of optical components

A common task in interferometry is measurement of the shape of a surface. This can be accomplished in two different ways. Either reflected light or the light transmitted through the surface could be used for the measurement.

Interferometric measurement is achieved by comparing the difference of two optical path lengths $\int nd$. Usually one path is called the reference path, the other the measurement path.

The resulting wave aberration, ΔW, for a displacement d of the surface, if measured in reflection, is $\Delta W = 2nd$. The same displacement measured in transmission results in the wave aberration $\Delta W = (n_2 - n_1)d$.

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