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Optics and photonics — Test methods for surface imperfections of optical elements

Optique et photonique — Méthodes d'essai applicables aux imperfections de surface des éléments optiques

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Foreword

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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).

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For an explanation on 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 the following URL: 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 third edition cancels and replaces the second edition (ISO 14997:2011), which has been technically revised to adapt ISO 14997 to the new version of ISO 10110-7.

The main change compared to the previous edition is as follows:

- the addition of language required to accommodate visibility inspection.

Introduction

Standard practice in the optics industry since the 1950s has been to visually inspect optical surfaces for small, localized imperfections and determine if they are acceptable.

This document was developed in response to worldwide demand for the standardization of test methods for surface imperfections. Surface imperfections, such as digs and scratches, arise from localized damage during or after manufacture. They can be visible as a result of the light they scatter, giving rise to a false impression of poor quality. Alternatively, this light can appear as unwanted veiling glare (stray radiation) in an image plane, or it can lead to degradation in signal quality at an image sensor. Imperfections can also provide centres of stress, eventually leading to failure of components exposed to high laser radiation power/energy densities. In most cases, however, surface imperfections are representative of the quality of workmanship and do not have any impact whatsoever on the performance of the component in question.

Since modern methods of surface examination are capable of atomic resolution, no surface is likely to be found totally free of localized imperfections. Most surfaces produced are satisfactory for their intended purpose, but a small proportion can have suffered obvious damage and will be reworked or regarded as unacceptable. This can leave some components that, although slightly damaged, can still be found acceptable, when tested, depending on the level of acceptability of surface imperfections requested by the customer and specified on drawings in ISO 10110-7. This document describes how these methods are implemented.

In some cases, it is necessary to measure or estimate the size of the imperfections on an optical surface. In other cases, however, it is necessary or desirable to assess their brightness or appearance, and not their size. In these cases, visual inspection is preferred over dimensional measurements.

This document describes the human evaluation of surface imperfections for the dimensional and visibility methods. New developments open the route to machine vision approaches which are more objective and exhibit an increased reproducibility, less conflict and an optimized production closer to the allowed specification, lowering cost[10],[11]. Some of these machine vision-based approaches may be able to validate the surface imperfection specifications of ISO 10110-7. It is incumbent upon the manufacturers and users of objective measurement equipment to demonstrate compatibility with the methods described herein and to report their results consistent with the notation described in ISO 10110-7.

It should be noted that other light scattering imperfections, which also need to be measured, can arise as digs distributed over the surface of an incompletely polished surface, and as bubbles and as striae within an optical material. The measurement of laser damage thresholds also requires sensitive means for quantifying the level of radiation scattered by damage in its early stages.

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1 Scope

This document specifies the physical principles and practical means for the implementation of methods for evaluating surface imperfections.

For imperfections specified using the visibility method, two inspection methods are described. The first is visual evaluation of the surface without any comparison standard (IV_V). The second is a visibility assessment of a surface imperfection when compared to an artefact of known brightness (IS_V).

For imperfections specified using the dimensional method, three methods are described. The first is visual evaluation of the surface without any comparison standard (IV_D). The second is a dimensional assessment of a surface imperfection when compared to an artefact of known size (IS_D). The third is the dimensional measurement of a surface imperfection using magnification and either a comparison artefact of known size or a reticle or ruler (IM_D).

Instruments exist that allow objective measurement of brightness (digital scatterometry) or size (digital microscopy). While these instruments can be used for evaluation of surface imperfections, they are beyond the scope of this document.

This document applies to optical surfaces of components or assemblies such as doublets or triplets.

This document can be applied to optical plastic components; however, attention is drawn to the fact that impact damage to plastic materials often looks very different from that on harder materials as it does not always result in the removal of material but instead can displace material, causing ripples in the surface. Consequently, visual comparisons of scratch and dig damage to plastic with those on glass or crystalline materials can give very different results.

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 9211-1, *Optics and photonics — Optical coatings — Part 1: Definitions*

ISO 10110-7, *Optics and photonics — Preparation of drawings for optical elements and systems — Part 7: Surface imperfections*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10110-7, ISO 9211-1 and ISO 11145 and the following apply.

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

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

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