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PRESSEINFORMATION

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Innovatives Design optischer Systeme stärkt die industrielle Messtechnik

SwissOptic veröffentlicht Fachartikel über die Herstellung kundenspezifischer Hochleistungsoptiksysteme

Bildsensoren haben sich in den vergangenen Jahren sehr stark entwickelt. Dadurch ist es heutzutage möglich, Bilder mit einer Auflösung von mehr als 100 Mega Pixel aufzunehmen, einige hundert Bilder pro Sekunde zu erzeugen und lesbare Signale bei schlechten Lichtverhältnissen zu erhalten. Aber exzellente Bildsensoren alleine reichen nicht, um die Anforderungen von industriellen, bildbasierten Messsystemen, 3-D-Scannern oder Machine Vision Systemen zu erfüllen. Es ist erforderlich, dass auch das optische Frontend mit einer höheren Leistung als je zuvor arbeitet.

Hochauflösende Sensoren verlangen nach Optiken, die sich nah an oder an der Beugungsgrenze befinden. Standardoptiken können nicht mehr in allen Anwendungen diesen Anforderungen gerecht werden. Es werden kundenspezifische optische Systeme benötigt, um die Sensoren mit genügend Informationen zu versorgen, um wirklich von ihrer Leistungssteigerung zu profitieren.

Der Fachartikel mit dem Titel „Innovative Design of Optical Systems Boosts Industrial Metrology", der in der aktuellen Ausgabe des Magazins EuroPhotonics (Ausgabe Autumn 2019) erschienen ist, erklärt, wie ein solches kundenspezifisches Hochleistungsoptiksystem entwickelt, hergestellt und montiert wird.
Es werden die folgenden Prozessschritte und die speziellen Herausforderungen jeder Phase detailliert beschrieben:

- Optik- und Mechanikdesign
- Präzisionsoptikfertigung
- Messtechnik
- Montage der Baugruppen

Der vollständige Artikel ist auf der EuroPhotonics Website zu finden:
https://www.photonics.com/Articles/Innovative_Design_of_Optical_Systems_Boosts/a64931

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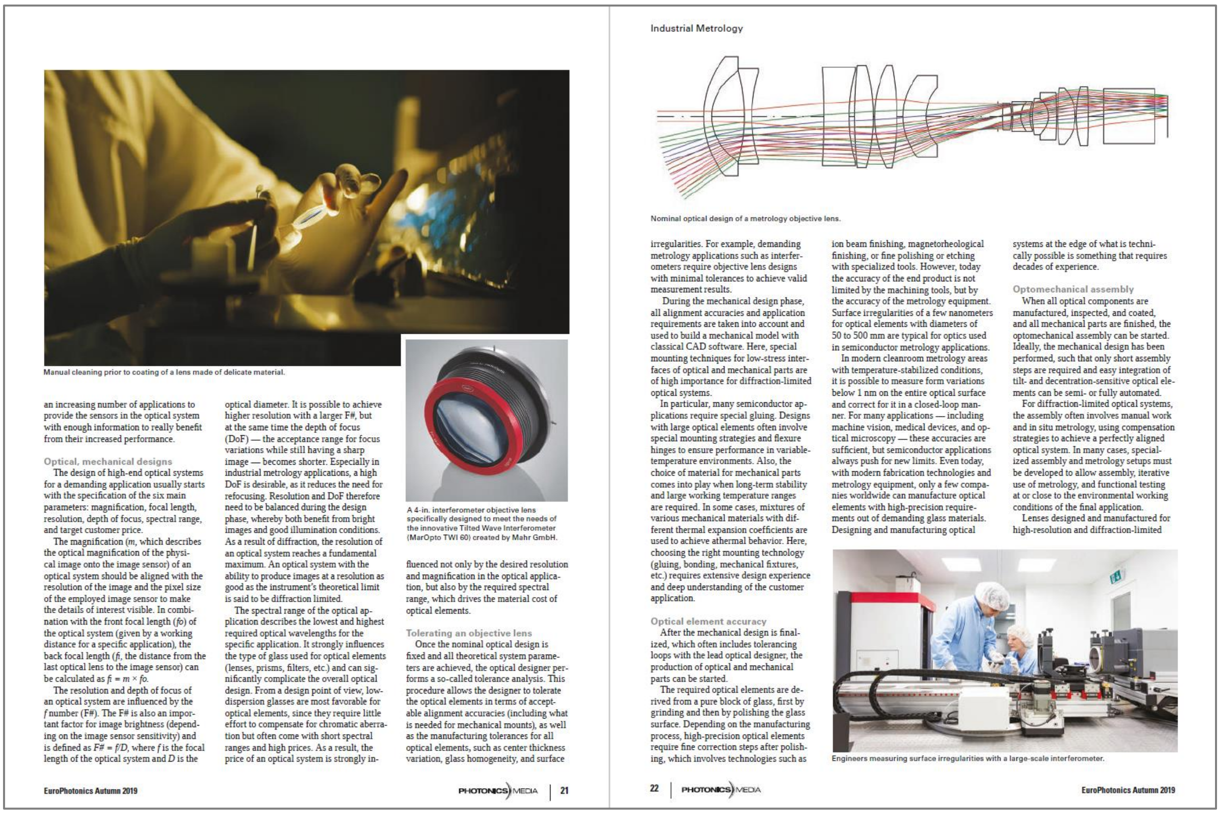
Weitere Informationen zu den Kompetenzen der SwissOptic AG erhalten Sie hier https://www.swissoptic.ag/.
Gern stehen Ihnen die Experten der SwissOptic AG auch persönlich zur Verfügung. Schreiben Sie einfach eine kurze Mail an marketing@berlinerglas.de, und wir stellen den Kontakt für Sie her.



Manual cleaning prior to coating of a lens made of delicate material.

an increasing number of applications to provide the sensors in the optical system with enough information to really benefit from their increased performance.

Optical, mechanical designs

The design of high-end optical systems for a demanding application usually starts with the specification of the six main parameters: magnification, focal length, resolution, depth of focus, spectral range, and target customer price.

The magnification (*m*, which describes the optical magnification of the physical image onto the image sensor) of an optical system should be aligned with the resolution of the image and the pixel size of the employed image sensor to make the details of interest visible. In combination with the front focal length (*fo*) of the optical system (given by a working distance for a specific application), the back focal length (*fi*, the distance from the last optical lens to the image sensor) can be calculated as $fi = m \times fo$.

The resolution and depth of focus of an optical system are influenced by the *f* number (F#). The F# is also an important factor for image brightness (depending on the image sensor sensitivity) and is defined as $F\# = f/D$, where f is the focal length of the optical system and D is the optical diameter. It is possible to achieve higher resolution with a larger F#, but at the same time the depth of focus (DoF) — the acceptance range for focus variations while still having a sharp image — becomes shorter. Especially in industrial metrology applications, a high DoF is desirable, as it reduces the need for refocusing. Resolution and DoF therefore need to be balanced during the design phase, whereby both benefit from bright images and good illumination conditions. As a result of diffraction, the resolution of an optical system reaches a fundamental maximum. An optical system with the ability to produce images at a resolution as good as the instrument's theoretical limit is said to be diffraction limited.

The spectral range of the optical application describes the lowest and highest required optical wavelengths for the specific application. It strongly influences the type of glass used for optical elements (lenses, prisms, filters, etc.) and can significantly complicate the overall optical design. From a design point of view, low-dispersion glasses are most favorable for optical elements, since they require little effort to compensate for chromatic aberration but often come with short spectral ranges and high prices. As a result, the price of an optical system is strongly influenced not only by the desired resolution and magnification in the optical application, but also by the required spectral range, which drives the material cost of optical elements.

A 4-in. interferometer objective lens specifically designed to meet the needs of the innovative Tilted Wave Interferometer (MarOpto TWI 60) created by Mahr GmbH.

Tolerating an objective lens

Once the nominal optical design is fixed and all theoretical system parameters are achieved, the optical designer performs a so-called tolerance analysis. This procedure allows the designer to tolerate the optical elements in terms of acceptable alignment accuracies (including what is needed for mechanical mounts), as well as the manufacturing tolerances for all optical elements, such as center thickness variation, glass homogeneity, and surface

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Industrial Metrology

Nominal optical design of a metrology objective lens.

irregularities. For example, demanding metrology applications such as interferometers require objective lens designs with minimal tolerances to achieve valid measurement results.

During the mechanical design phase, all alignment accuracies and application requirements are taken into account and used to build a mechanical model with classical CAD software. Here, special mounting techniques for low-stress interfaces of optical and mechanical parts are of high importance for diffraction-limited optical systems.

In particular, many semiconductor applications require special gluing. Designs with large optical elements often involve special mounting strategies and flexure hinges to ensure performance in variable-temperature environments. Also, the choice of material for mechanical parts comes into play when long-term stability and large working temperature ranges are required. In some cases, mixtures of various mechanical materials with different thermal expansion coefficients are used to achieve athermal behavior. Here, choosing the right mounting technology (gluing, bonding, mechanical fixtures, etc.) requires extensive design experience and deep understanding of the customer application.

Optical element accuracy

After the mechanical design is finalized, which often includes tolerancing loops with the lead optical designer, the production of optical and mechanical parts can be started.

The required optical elements are derived from a pure block of glass, first by grinding and then by polishing the glass surface. Depending on the manufacturing process, high-precision optical elements require fine correction steps after polishing, which involves technologies such as ion beam finishing, magnetorheological finishing, or fine polishing or etching with specialized tools. However, today the accuracy of the end product is not limited by the machining tools, but by the accuracy of the metrology equipment. Surface irregularities of a few nanometers for optical elements with diameters of 50 to 500 mm are typical for optics used in semiconductor metrology applications.

In modern cleanroom metrology areas with temperature-stabilized conditions, it is possible to measure form variations below 1 nm on the entire optical surface and correct for it in a closed-loop manner. For many applications — including machine vision, medical devices, and optical microscopy — these accuracies are sufficient, but semiconductor applications always push for new limits. Even today, with modern fabrication technologies and metrology equipment, only a few companies worldwide can manufacture optical elements with high-precision requirements out of demanding glass materials. Designing and manufacturing optical systems at the edge of what is technically possible is something that requires decades of experience.

Optomechanical assembly

When all optical components are manufactured, inspected, and coated, and all mechanical parts are finished, the optomechanical assembly can be started. Ideally, the mechanical design has been performed, such that only short assembly steps are required and easy integration of tilt- and decentration-sensitive optical elements can be semi- or fully automated.

For diffraction-limited optical systems, the assembly often involves manual work and in situ metrology, using compensation strategies to achieve a perfectly aligned optical system. In many cases, specialized assembly and metrology setups must be developed to allow assembly, iterative use of metrology, and functional testing at or close to the environmental working conditions of the final application.

Lenses designed and manufactured for high-resolution and diffraction-limited

Engineers measuring surface irregularities with a large-scale interferometer.

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Bild: Auszug aus dem Magazin EuroPhotonics (Ausgabe Autumn 2019)

Über die Berliner Glas Gruppe:
Die Berliner Glas Gruppe mit mehr als 1.500 Mitarbeitenden ist einer der weltweit führenden Anbieter optischer Schlüsselkomponenten, Baugruppen und Systeme, hochwertig veredelter technischer Gläser und Glas-Touch-Baugruppen. Mit dem Verständnis für optische Systeme und optische Fertigungstechnik entwickelt, fertigt und integriert die Berliner Glas Gruppe für ihre Kunden Optik, Mechanik und Elektronik zu innovativen Systemlösungen. Diese Lösungen kommen weltweit in der Halbleiterindustrie, der Laser- und Weltraumtechnik, der Medizintechnik, der Messtechnik und der Displayindustrie zum Einsatz.

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