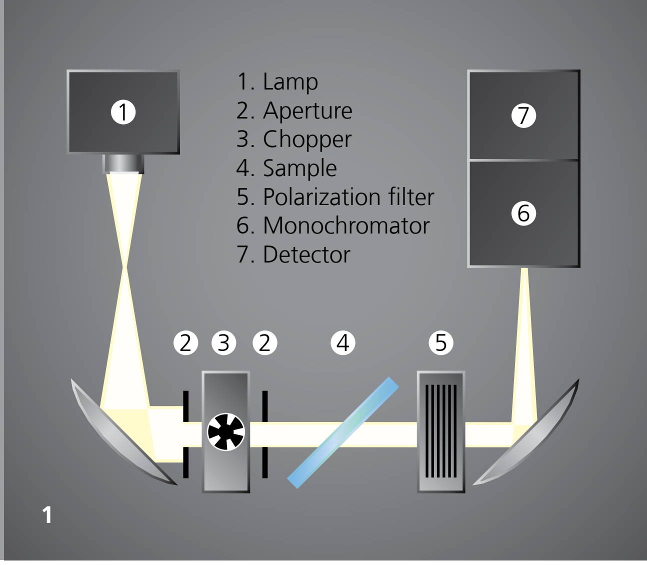

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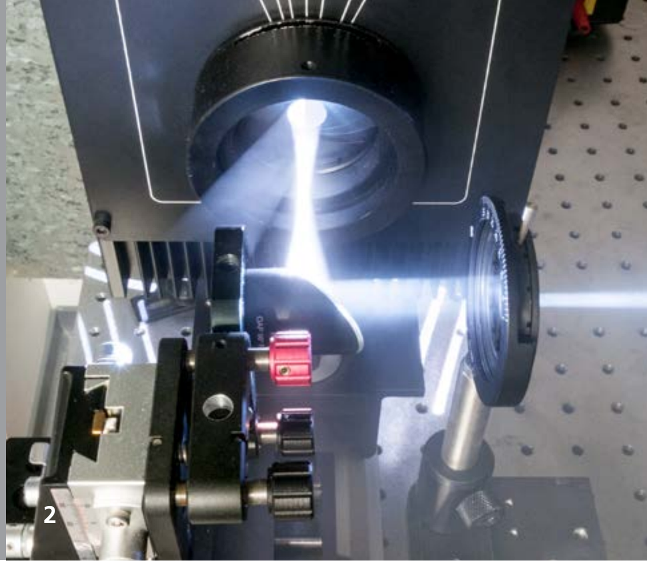
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INNOVATIVE SPECTROMETER WITH LOW DIVERGENCE

The interference filters required by industry and technology can be manufactured with the aid of thin-film technologies. The potential applications of these filters range from the simple anti-reflective coating of spectacle lenses, to digital projection technology, and on to special laser applications. However, high demands are often made of the filter spectrum, which means that characterization of the specifications, such as the full-widths at half maximum, is crucial for the quality analysis. Important spectrometer parameters for the measurement of optical interference filters include the spectral bandwidth and the divergence angle of the measuring beam. These two variables influence the width of fine structures in the spectrum of an interference filter and thereby limit the resolution of spectrally steeper edges in conventional spectrometers. Within the framework of the BMBF joint project "DAHLIA" a spectrometer with a smaller angle of divergence has therefore been built at the Fraunhofer IST.

The newly developed spectrometer in the measurement set-up

With the spectrometer featured here, transmission can be measured angle-dependently in a wavelength range of 240 to 1000 nm with an angle of divergence of 0.25°. The divergence angle set is reduced by a factor of 10 in comparison with a commercial spectrometer. In the measurements the monochromator can be set to a minimum spectral bandwidth of 0.06 nm. Since the spectrometer's measuring beam must have a maximum intensity at a low divergence angle for the measurements, a xenon arc lamp is used as the light source with this measurement configuration. In contrast to other light sources, the xenon arc lamp has a comparatively small light-emitting area and a high light density. Via a mirror and aperture system, a polychromatic measuring beam with a low divergence is generated (see Figure 2). After passing through the interference filter the measuring beam is input into a monochromator with a high-resolution diffraction grating (see Figure 3) and picked up by a low-noise detector. The measurement set-up is equipped with a chopper and can thus measure optical densities up to 4.

Test measurements with different angles of divergence

In order to show the broadenings of the structures as a function of the divergence angle, a sharp transmission structure of an interference filter was examined more closely. The filter was measured with a spectral bandwidth of 0.5 nm and an angle of incidence of 45° at the divergence angles of 0.25°–0.88°–1.15°–1.63°–2.06° (see top graph). During examination of the widths of the individual peaks, a quadratic relationship was found between half-width values and divergence angles. The lower graph shows the results from this test. Measuring beams with a small divergence angle were therefore required in order to characterize band-pass filters with small half-widths or long-pass filters with spectrally steep edges.

Outlook

The measuring range of optical density is to be extended in the future in order to resolve even lower intensities. This will enable the characterization, among other things, of narrow notch filters with very high blocking (>OD 7).

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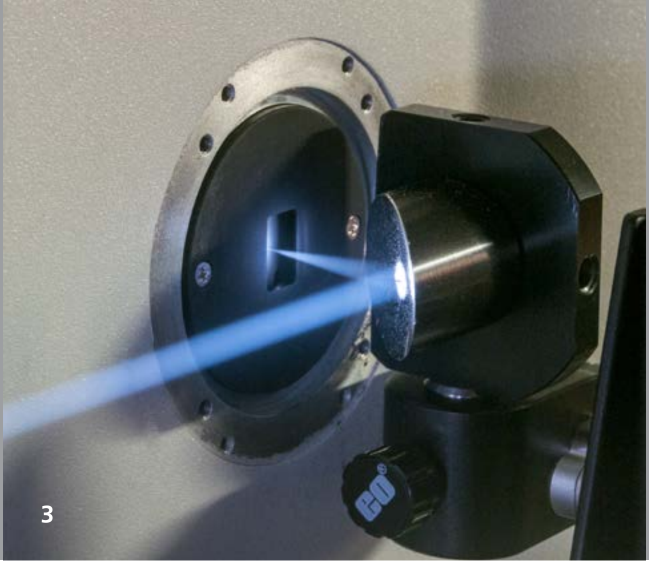
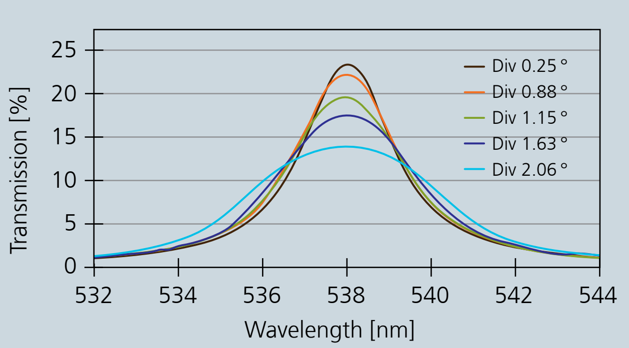
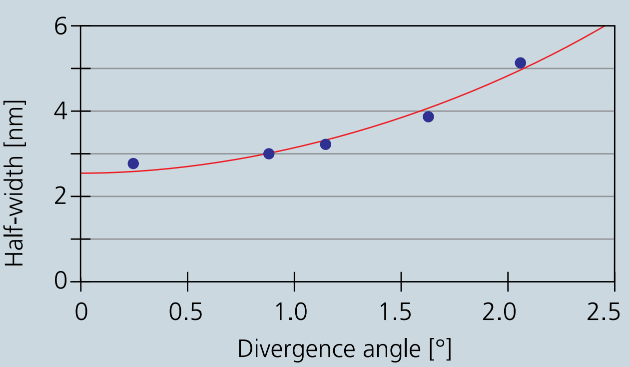


Comparison of the transmission spectra of a sharp structure at different angles of divergence (0.25°–0.88°–1.15°–1.63°–2.06°).



Comparison of the half-widths in transmission measurements of a sharp structure at different angles of divergence (0.25°–0.88°–1.15°–1.63°–2.06°).



1 *Schematic drawing of the spectrometer with a small divergence angle.*

2 *The measuring beam from the lamp is collimated with the aid of a mirror and aperture system.*

3 *Coupling the measuring beam into the monochromator.*

CONTACT

Chris Britze
Phone +49 531 2155-516
chris.britze@ist.fraunhofer.de

Fraunhofer Institute for Surface Engineering and Thin Films IST | Bienroder Weg 54 E | 38108 Braunschweig | Germany