DOI 10.5162/SMSI2023/P72

Angular Shift Compensation in Thermoformed Curved Thin-Film Interference Optical Filters

Hooman Banaei[1], Justin Boga[1], Bjoern Goetze[2], Johannes Kunsch[2]
[1] Everix Inc., 1468 N Goldenrod Rd, Suite 200, Orlando, FL 32807, USA
[2] Laser Components Germany GmbH, Werner-von-Siemens-Str. 15, 82140 Olching, Germany
hooman@everix.co

Summary:
Optical interference filters have an inherent blue shift at increasing angles of incidence (AOI). This angular shift leads to undesired constrains in optical sensor design. Curved filters can compensate such an angular shift considerably, enabling sensor designers to tighten the bandpass filter's band-width and improve SNR without compromising the field of view. This becomes possible since the opti-cal filters are manufactured like optical fibers, i.e. fundamentally different from conventional material deposition. Work is under progress and results will be presented post-deadline.

Keywords: Optical Filters, Angular Shift Compensation, Thin-Film Filters, PMMA, Curved Dielectric Filters

Introduction

We did run into this subject since we developed a new technology for making optical bandpass filters for consumer type applications [1]. Later on, it turned out that this technology allows for dielectric optical filters that are within ballpark of conventionally manufactured filters but have the advantage of freeform. So, we took a closer look into industrial applications and traditional constrains.

Optical interference filters feature an inherent blue shift of bandgap and spectrum at increas-ing angles of incidence (AOI). This angular shift leads to undesired constrains in optical sensor design. For instance, a bandpass filter utilized to suppress ambient noise in a range finder or face/gesture recognition sensor should ideally be as narrow as the bandwidth of the laser source used. However, to accommodate for the significant angular shift in the optical filter transmission curve, sensor designers have to broaden the bandwidth of such a bandpass filter. This results in undesired ambient noise that reduces the sensor's Signal-to-Noise Ratio (SNR).

Sketches of the thermal drawing principle and associated equipment are given in Fig. 1 and Fig. 2. Acrylic/PMMA based materials are used and a typical optical bandpass does consist of 800-1300 layers. The thermal drift is appr. 0.1 nm/K.

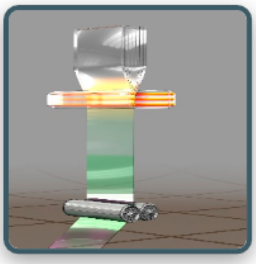

Fig.1 Dielectric optical interference filters are manufactured like optical fibers

Fig.2 Equipment for thermal drawing of optical filters

In this report, we demonstrate that 2- and 3-dimensionally curved filters can considerably compensate such an angular shift, enabling sensor designers to tighten the bandpass filter's bandwidth and improve SNR without compromising the field of view.

Description of the New Method or System

The thermal drawing technology provides the freedom of freeform filters. So, the basic idea is simple and illustrated in Fig.3: In order to avoid angular shift at angles of incidence under 45° the filter is shaped such, that the light enters this direction perpendicular.

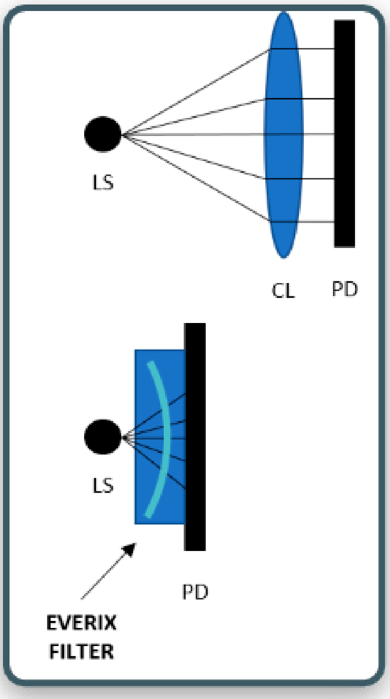

Fig.3 Basic sketch for angular correction by freeform filters in front of a photodetector.

Basically, this could also be achieved with conventional coating processes. However, in this case keeping film thickness independent of position becomes a challenge. Therefore, usually sub-complex designs are manufactured on curved substrates whereas the thermal drawing approach allows for more complex designs on curved substrates.

Results

Complex planar designs of thin film Single- and Multi-Notch Filters with typical FWHM of 5-8 % of the center wavelength and OD6 attenuation as well as bandpass filters with 5-100 nm FWHM have already been successfully implemented. Angular shift compensated filters are under work and results will be presented at the poster.

References

[1] H. E. Banaei, C.R. Nelson, Eyewear Article with Interference Filter, patent WO 2017/180828 A1, International Publication Date 19 October 2017