OIC 2019 Design Challenge

Organizers:

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Vladimir Pervak, *Ludwig-Maximilians-Universitaet Muenchen, Germany*

Evaluation:

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Problem Statement

The design problems for OIC 2019 involve a new look on an old problem and a light-mixing system.

Problem A requires solving a challenge originally from 2007, a nonpolarizing beamsplitter [1]. The OIC 2019 results will be compared to those from 12 years ago to see what, if any, significant advances have been made.

Problem B requires designing a light mixing system to add four light sources from four different paths to create one beam. The sources will be linearly polarized and the final result from the mixing system will produce an output that will have zero phase shift and as high a throughput as possible. Problem B has two parts, the first where all of the combining optics are in the same plane of incidence, and the second, where the center optic is in a plane orthogonal to the first and last combiner optic.

A web-based evaluation program will be available for designers starting November 1, 2018 to evaluate their solutions to these problems before they are submitted. The submissions will be evaluated using the same program as presented at OIC 2016. The submission deadline will be **April 26, 2019 by 11:59PM** Eastern Standard Time. As always, we hope designers will share their design approaches and insights.

Problem A - Nonpolarizing Beamsplitter

Optical systems that leverage polarization are still relevant today. These systems not only have requirements for phase (e.g. cell phones, high definition television, DVD players), but also the intensity of the outgoing light. This challenge entails designing a beam splitter that is nonpolarizing in both intensity and phase with the following specifications:

1. Angle of incidence: 45°.
2. Nominal center wavelength: 550nm.

3. $R_s = R_p$, within 2%.
4. $40\% \leq R_s \leq 60\%$ and $40\% \leq R_p \leq 60\%$.
5. Phase difference on reflection: $\delta\phi R = 0°$, within $1°$ (absolute value of the difference in the p and s reflected phase).
6. Phase difference on transmission: $\delta\phi T = 0°$, within $1°$ (absolute value of the difference in the p and s transmitted phase).

There are two definitions for $\delta\phi R$ for p-polarized light, and they differ by 180°. E. Spiller documents the phase conventions [2], where the reflected waves in s and p have no phase difference at normal incidence (Abelès convention) or 180° difference (Mueller convention). This challenge will accept solutions that meet the $\delta\phi R = 0°$ requirement by using either convention.

The spectral bandwidth will be considered around the center wavelength of 550 nm. This would mean that a design that met the requirements from 548nm to 552 nm would win over a design that met the requirements from 548.5 nm to 553 nm. The substrate is considered semi-infinite, with only one surface, therefore performance of the design will be for a single-surface only. The index information for the medium, substrate, and film layers are in Table 1.

Dielectric Layer Materials	Medium / Substrate
(Symbol = n)	
F = 1.38	$n_{\text{medium}} = 1.0$
L = 1.45	$n_{\text{substrate}} = 1.52$
E = 1.65	
M = 1.8	
D = 2.05	
T = 2.2	
H = 2.35	

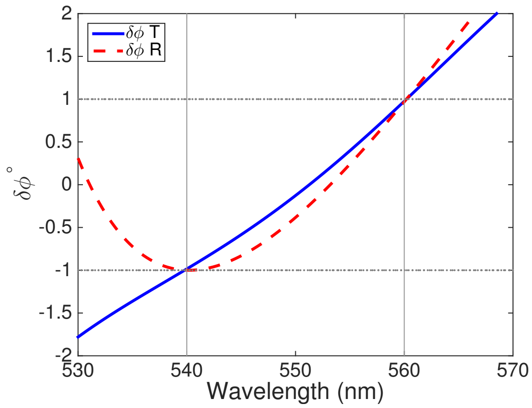
Table 1

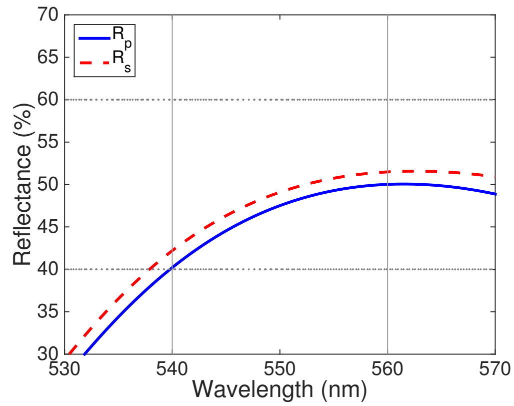
Other design limitations include:

- Minimum layer thickness: 5 nm.
- Maximum number of materials used in a single design: 3.

The designs will be evaluated at a 0.001nm interval. There are no limitations on the number of layers or the total physical thickness of the coating design. However, in the event of a tie, the design with the thinnest total physical thickness will be deemed the winner.

Example Problem A Design





	Material	Phys. Thkns (nm)
1	F	450.909
2	M	66.682
3	H	58.569
4	M	91.766
5	F	40.059
6	H	7.259
7	F	39.647
8	M	83.56
9	H	25.89
10	F	14.939
11	H	24.22
12	M	84.184
13	H	63.123
14	M	67.73
15	F	139.867
16	M	71.428
17	H	37.868
18	F	9.151
19	H	18.716
20	M	88.092
21	H	60.435
22	M	68.891
23	F	55.603
24	H	65.283
25	M	13.321
26	F	107.624

Problem B - Light Mixing System

Problem B entails combining four narrow-bandwidth light sources, with differing peak wavelengths, at various locations in an optical mixing system to produce a single beam at the output. There are three substrates that are used for mixing, and six surfaces that shall be coated to guarantee the maximum output of all four sources from 400 to 700 nm, every 1 nm. Each substrate is at an angle of incidence (AOI) of 35 degrees. The optical setup is shown in Figure 1 and the sources are shown in Figure 2. The data for the sources can be found at http://clearapertures.com/oic2019/.

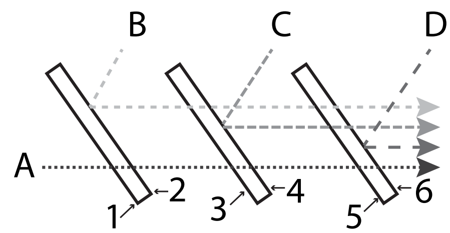


Figure 1: Light mixing system. A, B, C, and D are the locations of entry for the four sources. Each substrate is at 35 degrees AOI.

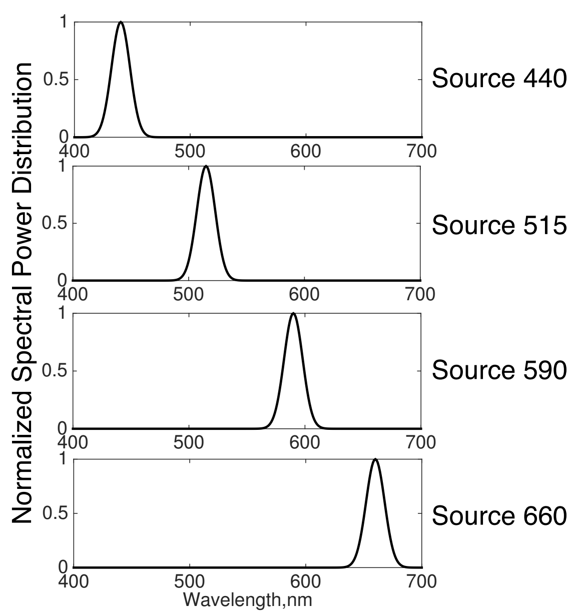


Figure 2: Four narrow band sources, described by their peak wavelength; 440, 515, 590, and 660.

Each designer has the choice of source entry points. Source A will transmit through coatings 1 through 6. Source B will reflect off of coating 2 and transmit through coatings 3 through 6. Source C will reflect off of coating 4 and transmit through coatings 5 and 6. Source D will only reflect off of coating 6. The target system output can be viewed in Figure 3.

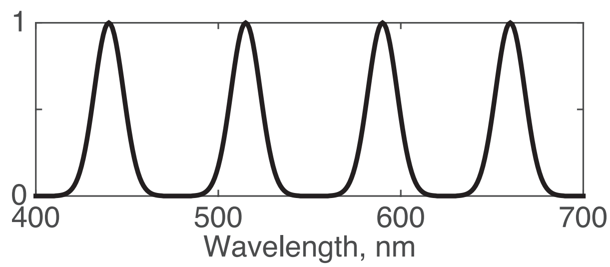


Figure 3: Goal output for Problem B.

Problem B.1 - Same Plane of Incidence

The goal for B.1 will be to design a mixing system with the highest throughput. All four sources are polarized for both S and P. The polarization states start off in phase and must be in phase upon exiting the system (i.e. zero degree phase difference between S and P). What happens to the phase difference in the system does not matter, only the exiting beams must have as close to a zero phase difference as possible. All six surfaces are in the same plane of incidence, therefore, the phase differences ($\delta\phi_\lambda$) will add for each source from each surface to produce the final phase difference of said source upon exiting the system. So an example for source B would be:

$$\delta\phi_{\text{total B},\lambda} = \delta\phi R_{2,\lambda} + \delta\phi T_{3,\lambda} + \delta\phi T_{4,\lambda} + \delta\phi T_{5,\lambda} + \delta\phi T_{6,\lambda} \quad (1)$$

where R is reflectance and T is transmittance.

The material refractive indices for the substrate, medium, and layers are found in Table 2. The coating requirements are the following:

1. Every surface must have at least one thin film layer on it. No bare surfaces allowed.
2. The thinnest layer of any design cannot be < 5 nm.
3. The thickest layer of any design cannot be > 1000 nm.
4. The total number of layers in any design cannot be > 100.
5. The phase difference of each coated surface (upon transmission or reflection) should be determined between –180 to 180 degrees ($-\pi$ to π radians).
6. The phase difference is the amount of phase change (on reflection or transmission) for S minus P polarization.

The merit function (MF) of problem B.1 will be:

$$\text{MF} = \left(\frac{1}{N} \sum_{j=1}^{N} \frac{(O_{j,p} - O_j')^2}{\Delta O_j} \right)^{\frac{1}{2}} + \left(\frac{1}{N} \sum_{j=1}^{N} \frac{(O_{j,s} - O_j')^2}{\Delta O_j} \right)^{\frac{1}{2}} + \left(\frac{1}{N} \sum_{j=1}^{N} \frac{\left(\delta\phi_{A,j} L_{A,j} + \delta\phi_{B,j} L_{B,j} + \delta\phi_{C,j} L_{C,j} + \delta\phi_{D,j} L_{D,j}\right)^2}{\Delta\delta\phi_j} \right)^{\frac{1}{2}} \quad (2)$$

where $O_{j,p}$ or $O_{j,s}$ are the final output of the system at a specified wavelength λ_j for p or s polarization, O'_j is the output target, ΔO_j is the output weighting factor, N=301 wavelengths, $\delta\phi_{\_,j}$ is the final output phase difference for each source light, $L_{\_,j}$ (A, B, C, or D), of the system at a specified wavelength λ_j, and $\Delta\delta\phi_j$ is the phase difference weighting factor. For this problem $\Delta O_j = 0.001$ and $\Delta\delta\phi_j = 200$. One will notice the phase difference for each light path is multiplied by the appropriate source. This will assure that for this part of the merit function, the phase difference for wavelengths with zero light will not be considered.

Dielectric Layer Materials	Metal Layer Materials
(Symbol = n)	(Symbol = n, k)
F = 1.38	Ag = 0.12, 3.45
L = 1.45	Au = 0.306, 2.88
E = 1.65	Ni = 1.8, 3.33
M = 1.8	—-
D = 2.05	—-
T = 2.2	$n_{\text{substrate}} = 1.52$
H = 2.35	$n_{\text{medium}} = 1.0$

Table 2

Problem B.2 - Orthogonal Plane of Incidence

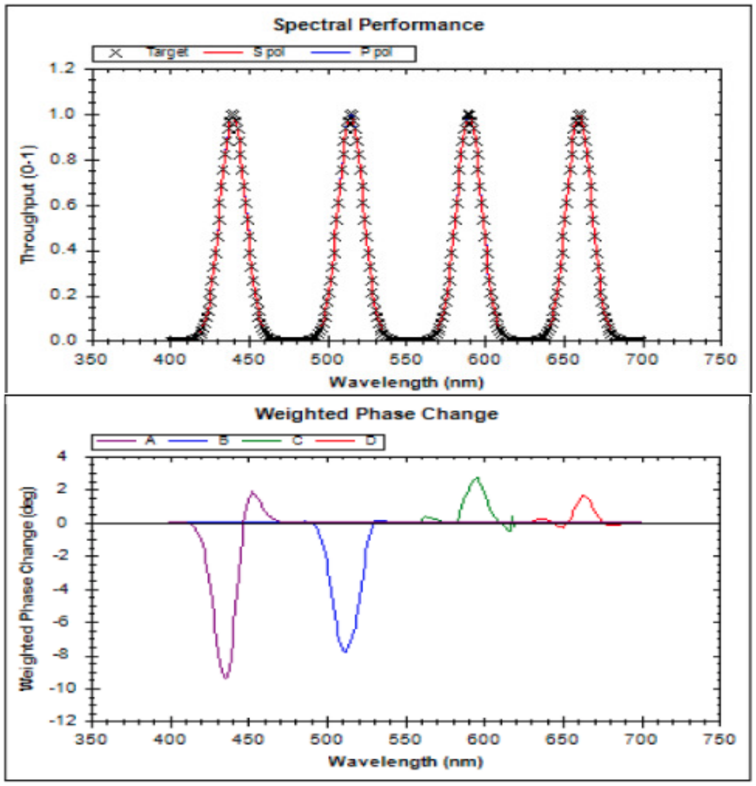
Everything is the same for problem B.2 as in B.1 (i.e., materials, targets, etc.). The only difference is that the middle optic is orthogonal to the plane of incidence of the left and right optic in the system. Orthogonal means that that optic is rotated 90 degrees to the plane of incidence to the other two. In this situation, S polarization becomes P, and P polarization becomes S. Therefore, instead of every phase difference of every surface being additive, as in Equation 1, for a system where one optic is orthogonal to the others we get for source B:

$$\delta\phi_{\text{total B},\lambda} = \delta\phi R_{2,\lambda} - \left(\delta\phi T_{3,\lambda} + \delta\phi T_{4,\lambda}\right) + \delta\phi T_{5,\lambda} + \delta\phi T_{6,\lambda} \quad (3)$$

In the event of a tie for either Problem B.1 or B.2 the thinnest total physical thickness including all six designs together will be deemed the winner.

Problem B.1 Example

Download the example designs at http://clearapertures.com/oic2019/. The MF for the spectral throughput for the example designs for B.1 was calculated to be approximately 0.3682 (0.1833 for the spectral component and 0.1848 for the phase component). Step by step analysis of this example can be found in the Appendix.



Submission

Participants are welcome to submit up to five designs for Problem A, and five system designs for Problems B.1 and/or B.2. Depending on merit, a submitted design may be published as part of a paper presented at OIC 2019, and later in a special OIC 2019 issue of Applied Optics. Until then, any submitted design will be known (and kept confidential) only by the OIC Design Contest team, the OIC 2019 General and Program Chair persons, and some OSA staff members.

The submission should be in the form of a DOS/Windows-based text file (i.e. a '.txt' extension) that should be either tab or space delimited. The filename should be the last name of the author shortened to six letters followed by three identifying characters. (If the author name is less than six characters, underscore characters should fill the extra spaces.) An example submission format for Problem A is shown below.

Filename: PervakA_1.txt [six characters for name, problem A, underscore, 1st submission]

line 1 Name, Affiliation
line 2 Email address
line 3 - *blank* - [delimits start of design]
line 4 D 200 [material and layer thickness in nm for layer 1]
line 5 H 55 [material and layer thickness in nm for layer 2]
line 6 L 215 [material and layer thickness in nm for layer 3]
...
line end H 315 [material and layer thickness in nm for last layer]

For Problem B submissions, line 3 should give the order of light sources entering the system at point A, B, C, or D respectively. Skip a line below the source information line to delimit that the design for surface 1 is starting. Also, skip a line between each of the six designs. An example format for Problem B is shown below.

Filename: KruschB11.txt [six characters for name, problem B.1, 1st submission]

line 1 Name, Affiliation
line 2 Email address
line 3 590 660 440 515 [Source (in nm) corresponding to A B C D]
line 4 - *blank* - [delimits start of design 1]
line 5 D 200 [material and layer thickness in nm for layer 1]
line 6 H 55 [material and layer thickness in nm for layer 2]
line 7 L 215 [material and layer thickness in nm for layer 3]
...
line 105 M 34 [material and layer thickness in nm for layer 100 of design 1]
line 106 - *blank* - [delimits start of design 2]
line 107 H 100 [material and layer thickness in nm for layer 1 of design 2]
line 108 D 25 [material and layer thickness in nm for layer 2 of design 2]
...
line 207 F 131 [material and layer thickness in nm for layer 100 of design 2]
line 208 - *blank* - [delimits start of design 3]
line 209 L 45 [material and layer thickness in nm for layer 1 of design 3]
...
line 309 H 62 [material and layer thickness in nm for layer 100 of design 3]
line 310 - *blank* - [delimits start of design 4]
...
line 412 - *blank* - [delimits start of design 5]
...
line 514 - *blank* - [delimits start of design 6]
...
line 615 D 35 [material and layer thickness in nm for layer 100 of design 6]

The evaluation webpage can be found at url: http://clearapertures.com/oic2019/ and will be available for use on November 1, 2018 until **April 26, 2019 by 11:59PM** Eastern Standard Time, when the submitted designs are due.

Submit your final designs to design.contest@clearapertures.com with the email subject line: OIC Submission.

The only requirement for participation in the contest is the submission of a design in the correct text format prior to the submission deadline. However, design authors are encouraged to accompany their designs with an explanation of how they arrived at their solutions. Questions regarding the evaluation program should be directed to Jason Keck at jkeck@clearapertures.com. Questions regarding the design problems and explanations of design submissions please contact Jennifer Kruschwitz and Vladimir Pervak at design.contest@clearapertures.com.

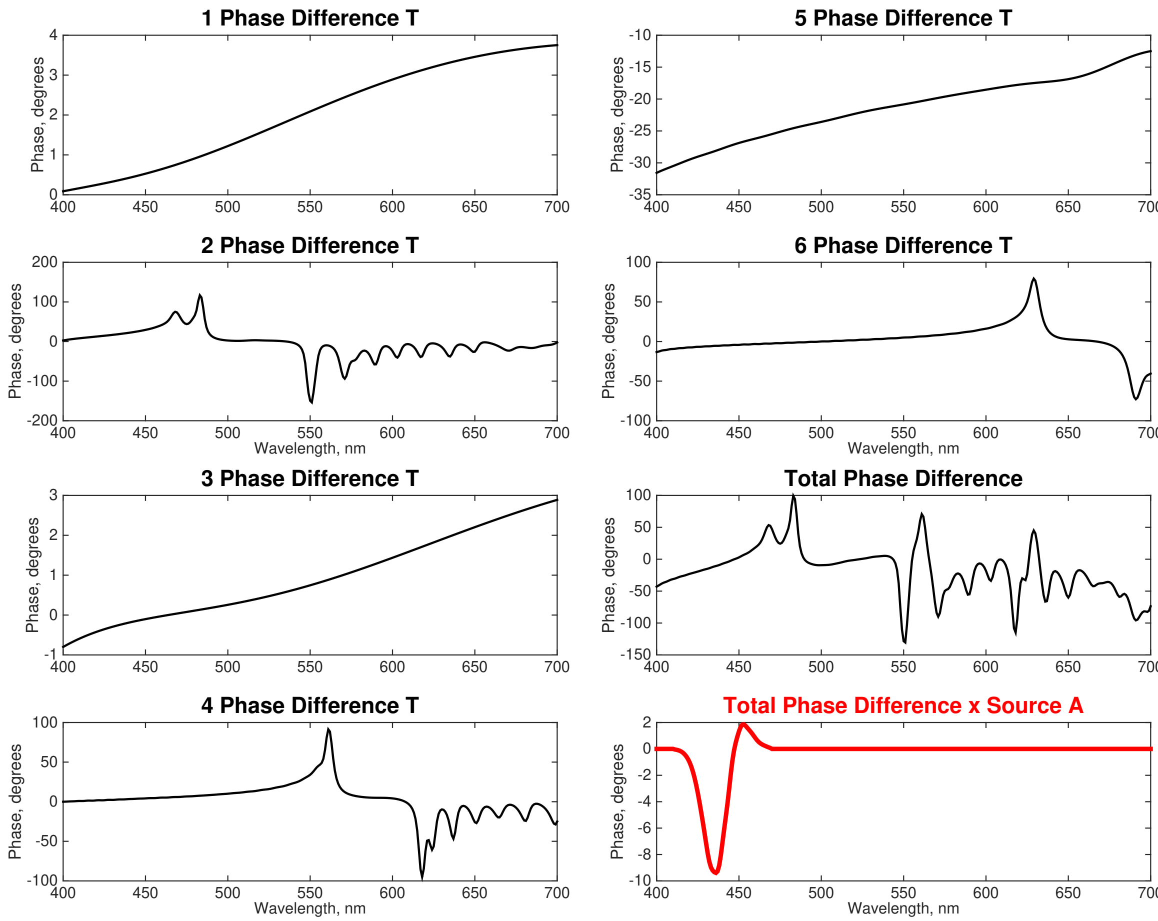
References

[1] M. Tilsch and K Hendrix, “Optical interference coatings design contest 2007: triple bandpass filter and nonpolarizing beam splitter”, Appl. Opt. 47, No. 13, C55-C69 (2008).

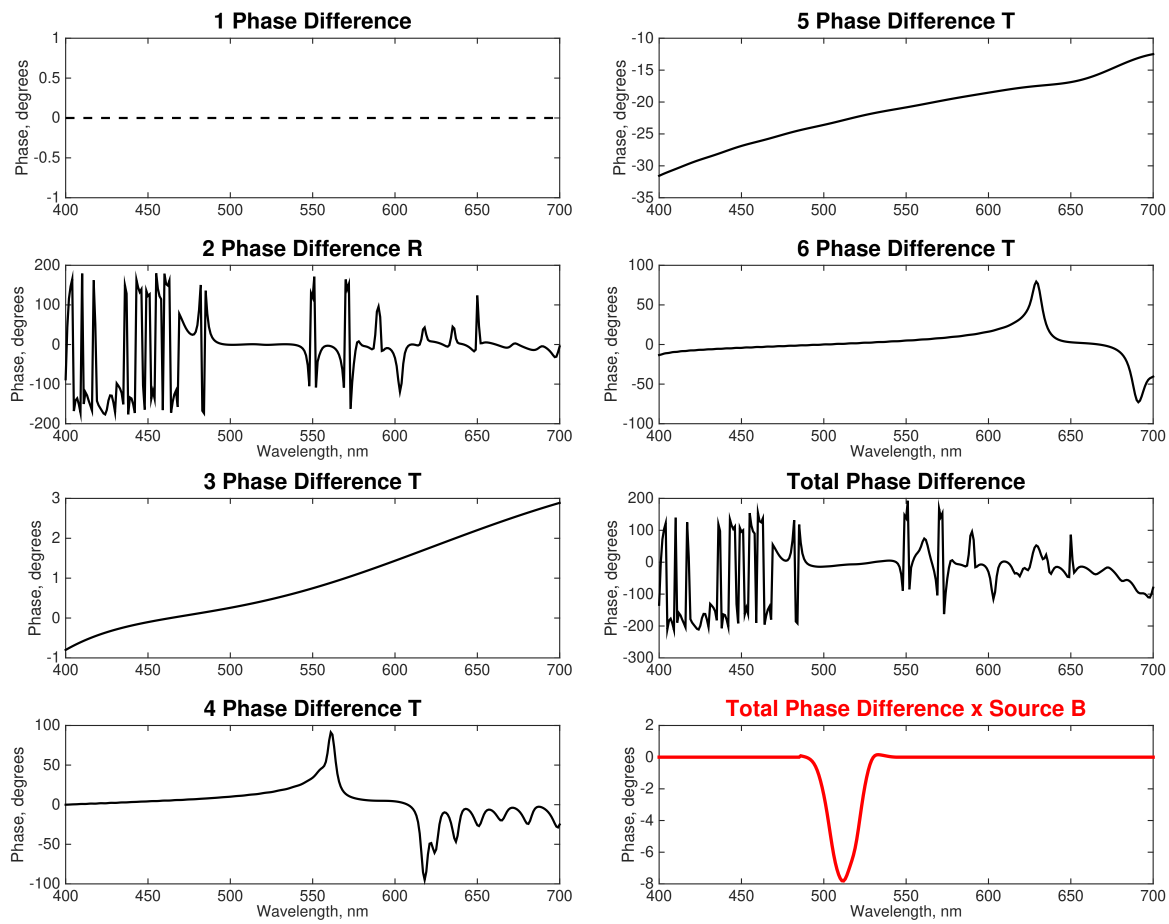
[2] E. Spiller, “Phase conventions in thin film optics and ellipsometry,” Appl. Opt. 23, 3036-3037 (1984).

Appendix

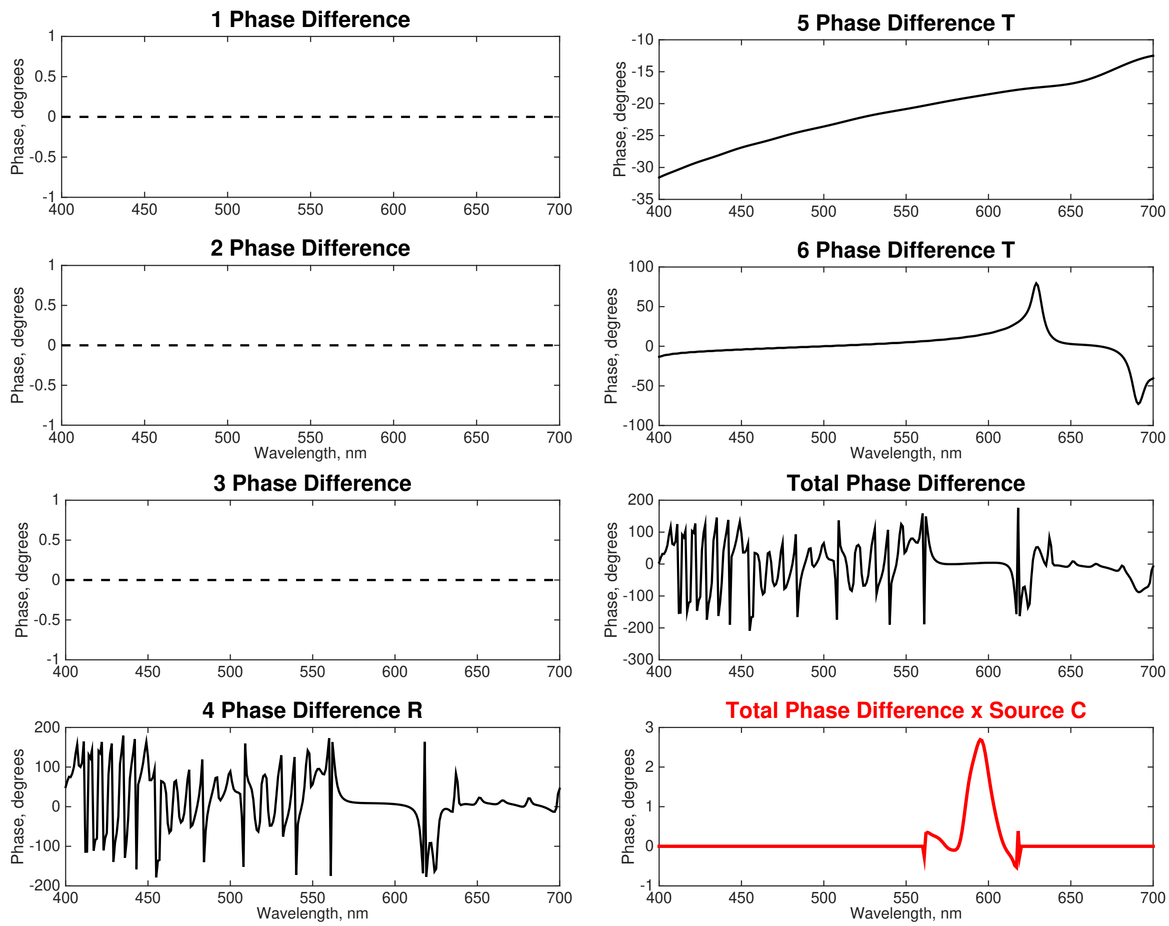
The following plots are the δϕ for each surface in Path A, and the total δϕ for Path A using the example design from Problem B.1:



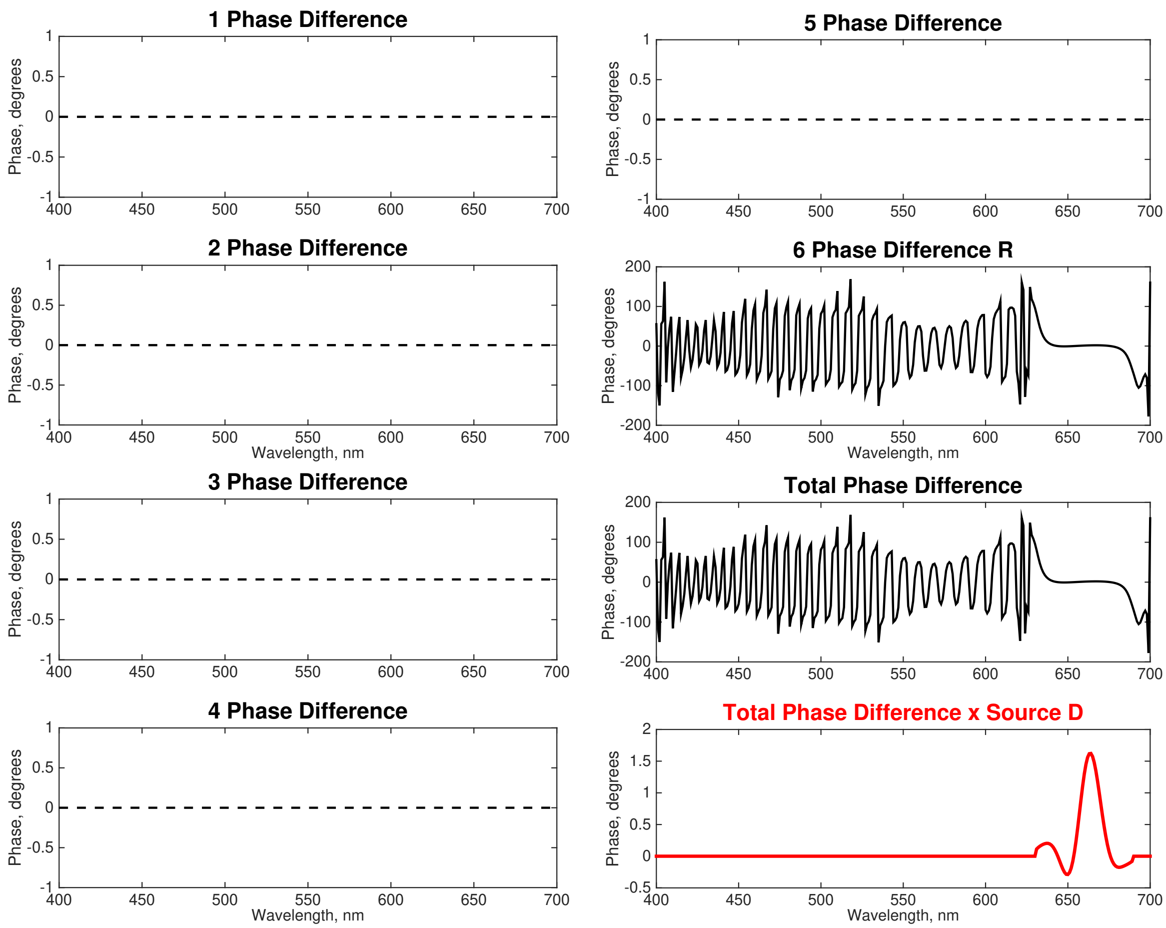
The following plots are the δϕ for each surface in Path B, and the total δϕ for Path B using the example design from Problem B.1 (notice there is no phase difference for surface 1):



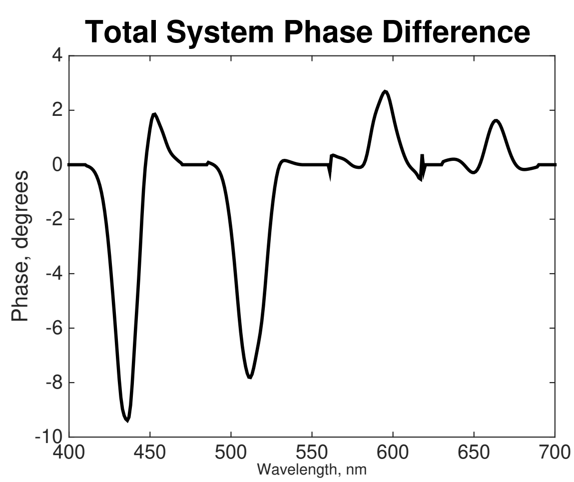
The following plots are the δϕ for each surface in Path C, and the total δϕ for Path C using the example design from Problem B.1 (notice there is no phase difference for surfaces 1-3):



The following plots are the δϕ for each surface in Path D, and the total δϕ for Path D using the example design from Problem B.1 (notice there is no phase difference for surfaces 1-5):



Where the total phase difference for the system in Problem B.1 Example is:



OIC 2019 Manufacturing Problem Contest

Organizers:

Daniel Poitras and Li Li
National Research Council of Canada, Ottawa, Canada.

Evaluation Team:

Michael Jacobson, *Optical Data Associates, Tucson, USA.*
Catherine Cooksey, *National Institute of Standards and Technology, Gaithersburg, USA.*

1. Introduction

For the 2019 Optical Interference Coatings Conference, we would like to propose another challenging Manufacturing Problem. As in the previous manufacturing contests, the objective of this contest is to provide valuable insight into the state-of-the-art capability in manufacturing complex thin film optical coatings.

In the OIC 2019 Manufacturing Problem Contest, the targeted wavelength region remains in the visible and near infrared as in the last contests. This time the problem has two transmittance curves defined at two different angles of incidence (both for s-polarization) specified as targets. As before, no specific suggestions are given with regard to the coating materials, the coating design and deposition processes. These are left to the participants to decide. The only basis for the evaluation of submitted samples will again be the measured performance, which will be carried out by two independent laboratories.

We require participants to submit their samples before the deadline of ***10 February 2019***.

Good luck to all participants!

2. Problem description

The OIC 2019 Manufacturing Problem covers both the visible and near infrared regions and is defined from 450 nm to 1075.0 nm. The target performance of the problem is specified as s-polarized transmittance curves at 10° and 50° angles of incidence (AOI), as shown in Figure 1 and listed in Appendix A. An Excel file of the filter specifications is also provided for downloading from the OIC 2019 web page.

The merit function *MF* defined below will be used to evaluate the performances of the submitted samples:

$$MF = \left\{ \frac{1}{(N_{10} + N_{50})} \left[\sum_{i=1}^{N_{10}} \left(\frac{T_{s10,i} - T_{s10,i}^{D}}{\Delta T_{s10,i}} \right)^2 + \sum_{i=1}^{N_{50}} \left(\frac{T_{s50,i} - T_{s50,i}^{D}}{\Delta T_{s50,i}} \right)^2 \right] \right\}^{1/2}, \qquad (1)$$

where $T_{s10,i}$, $T_{s10,i}^{D}$ are the measured and target transmittance values at 10° angle of incidence, and $T_{s50,i}$, $T_{s50,i}^{D}$ are the measured and target reflectance values at 50° angle of incidence, both for s-polarized light, at the specified wavelength λ_i; N_{10} and N_{50} are the total number of wavelengths defining $T_{s10,i}^{D}$ and $T_{s50,i}^{D}$ targets; $\Delta T_{s10,i}$ and $\Delta T_{s50,i}$ are the transmittance tolerances.

A number of numerical solutions to this problem have been found that are based on different coating materials and with different total number of layers and overall layer thicknesses. Manufacturing simulations with random errors have shown that the problem is not trivial if a good performance is to be achieved.

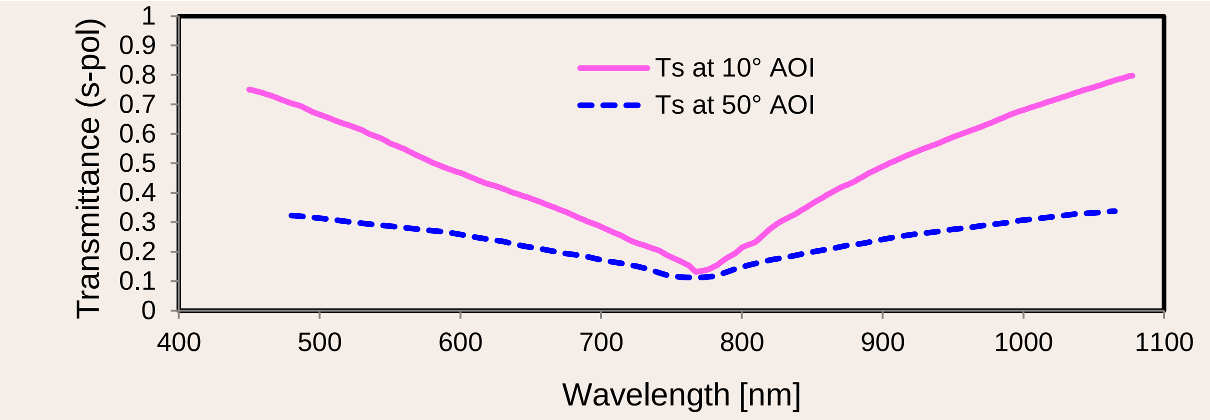


Figure 1 - The transmittance targets for OIC 2019 Manufacturing Problem Contest

As we all know, in the manufacture of practical optical coatings, deposition processes and filter designs are often selected not only to produce satisfactory optical performance, but also to meet other non-optical requirements, such as manufacturing cost, mechanical properties, durability, etc. Therefore, many compromises have to be made with different constraints and often there are no optimal solutions that can be applicable to all situations. For this reason, we encourage the optical thin film community to try using different processes to fabricate the filter for the contest (for example, e-beam evaporation, sputtering, or plasma deposition), as those processes are commonly used in many places.

3. Sample preparation

3.1 Intent of participation

Please notify the organizers by email (daniel.poitras@nrc-cnrc.gc.ca, Li.Li@nrc-cnrc.gc.ca) of your intent to participate in the manufacturing problem. We will send you the required number of substrates (maximum 3 per team). The substrates are once again donated by *Edmund Optics*. If more substrates are required, the participants will have to purchase them on their own (part number 34-427 at *Edmund Optics*). Please note that an organization (company, university, research institute) can have more than one team participating to the contest (but no more than 3 teams); however, it can only submit a maximum of three samples, each of which with a different filter design.

3.2 Substrate specification and coating location

To minimize any problems in the performance evaluation, all multilayer coatings of the submitted samples are required to be deposited on standard blank substrates according to following specifications:

- *Material:* Schott N-BK7
- *Size:* 50.0 mm diam. × 1.0 mm thick
- *Coating location:* Center of the substrate
- *Minimum coated area:* 30 mm × 30 mm
- *Marking (see Figure 2):* Two black dots near the edge on the front side, marking the participant’s preferred axis of rotation for measurements at oblique incidence. (In order to prevent the impact of any form of anisotropy on the performance evaluation.)

Please note that the measurement labs will not be able to scan multiple locations on the sample in order to find the one exhibiting the best performance.

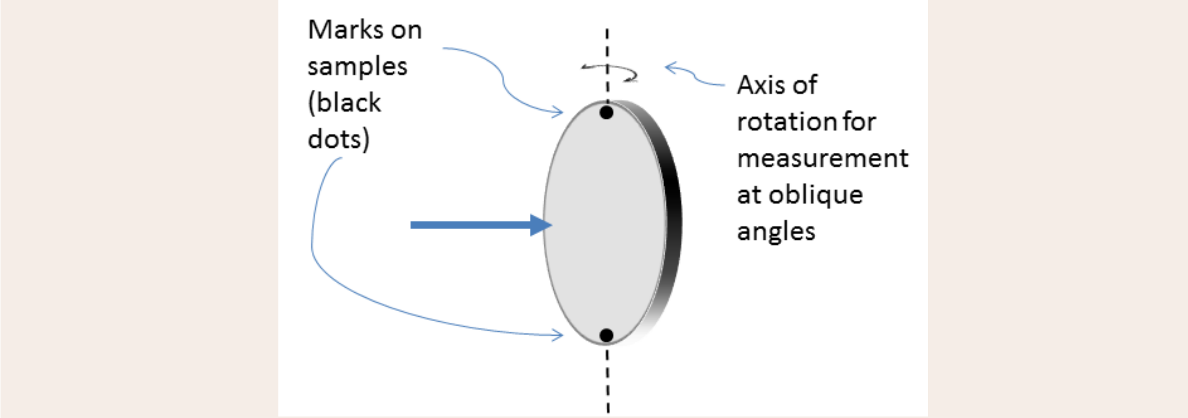


Figure 2 - Marking of the submitted samples.

3.3 Coating materials and durability

No toxic or radioactive materials such as ZnSe, ThF_4 should be used in the fabrication of the submitted samples because of strict regulations that exist in some jurisdictions. Other than this, participants are encouraged to use any materials that they feel are suitable and that will survive normal handling during the evaluation. Un-measurable samples will be disqualified.

4. Submitting samples

For the presentation of the OIC 2019 Manufacturing Problem Contest at the conference and also for the paper to be submitted for publication, we need not only to evaluate the samples but also show the layer designs in an electronic form in order to plot the refractive index profiles and the transmittance data from 450 nm to 1075 nm (with 1.0 nm steps) as measured by the participants, including measurements at normal incidence (0°) for control purpose. The organizers recognize that many groups are very protective of their design methods and deposition processes. Therefore, such information is not required, though participants are encouraged to provide as many details as they can so that the whole thin film community can learn and benefit from this exercise because their contributions.

The deadline for sending the samples is ***10 February 2019***. Each participating organization (one or multiple teams) can submit a maximum of three samples with different designs. Please use the provided Excel file for submitting data (see Appendix A). The sample submission should include the following items:

- Index profile [refractive index *n* and extinction coefficient *k* at a wavelength of 750 nm, and layer thickness) and calculated MF in electronic form.
- Measured transmittance at 0° (for control), 10° and 50° AOI, s-polarization, and estimated merit function in electronic form
- Suitably packed sample(s) to be sent to:

Dr. Daniel Poitras
c/o OIC 2019 Manufacturing Problem Contest
Building M50, Room IPF103
Photonics Team
Advanced Electronics and Photonics Research Center
National Research Council Canada
1200 Montreal Road | Ottawa, Ontario, Canada K1A 0R6
Tel: 613-990-5965 | Fax: 613-952-5711
daniel.poitras@nrc-cnrc.gc.ca

Please use a courier service for sending the samples (regular and registered mails are unreliable in terms of delivering time). Please also specify that the samples are for evaluation purpose only and they have no commercial value. Once you have sent your sample(s), please notify the organizers by email so that we will know when to expect the package. We will send you a confirmation email once we receive your sample(s).

5. Evaluation and results

Once received, the submitted samples will first be assigned random numbers and will then be sent, in identical packages, to the two independent laboratories for evaluation measurements. Neither of evaluation labs is allowed to submit a sample to the OIC 2019 Manufacturing Problem Contest. The target transmittance curves at the polarization, angles of incidence and wavelengths specified in Appendix A will be measured with dual-beam spectrophotometers. The measured merit functions will be then calculated based on Eq. (1) and the averaged merit function measured by the two labs will be used to rate the corresponding sample.

Measurement conditions:

- Beam divergence: approximately f/6
- Beam size: < 18 mm in diameter
- Angle of incidence: normal incidence (0°), 10° and 50°
- Polarization: S-polarization
- Wavelength steps: 1 nm
- Spectral bandwidth: 2 nm
- Measured location: at the center of the substrate

Apart from the above measurements, the samples will not be submitted to any other analytical measurements and analysis, such as Auger, SEM or TEM. All samples will be returned to the participants at the conference after the presentation of the results. Before and after measurements, the samples will be kept indoor and under normal ambient conditions of temperature and humidity.

The results of the Manufacturing Problem Contest will be presented at the *Optical Interference Coatings* conference in June 2019 and a more detailed report will be submitted for publication in *Applied Optics*.

6. Anonymous participation

As for the last Manufacturing Problem Contest in 2016, the measured performance of the samples will not be publicly linked to their creators. The names and affiliations of all the participants will be listed in the presentation at the OIC 2019 conference and also in the subsequent paper submitted to *Applied Optics*. The participants will be able to recognize the relative ranking of their own contributions, but no one else will. We would like to ask all participants to respect the anonymity rule and not to share information about their ranking in order to protect other participants and also to ensure the continuous participation of future contests.

One exception is that the identity of the team with the best result will be announced at the OIC 2019 Conference.

References of previous contests

1. J.A. Dobrowolski, S. Browning, M. Jacobson and M. Nadal, "Topical Meeting on Optical Interference Coatings (OIC' 2001): Manufacturing Problem," Appl. Opt. 41, 3039-3052 (2002).
2. J.A. Dobrowolski, S. Browning, M. Jacobson and M. Nadal, "2004 Optical Society of America's Topical Meeting on Optical Interference Coatings: Manufacturing Problem," Appl. Opt. 45, 1303-1311 (2006).
3. J.A. Dobrowolski, S. Browning, M. Jacobson and M. Nadal, "2007 Topical Meeting on Optical Interference Coatings: Manufacturing Problem," Appl. Opt. 47, C231-C245 (2008).

4. J.A. Dobrowolski, Li Li, M. Jacobson and D.W. Allen, "2010 Topical Meeting on Optical Interference Coatings: Manufacturing Problem," Appl. Opt. 50, C408-C419 (2011).
5. Li Li, J.A. Dobrowolski, Michael Jacobson and Catherine Cooksey "Broadband transmission filters from the 2013 Optical Interference Coatings manufacturing problem contest," Appl. Opt. 53, A248-A258 (2014).
6. Daniel Poitras, Li Li, Michael Jacobson, and Catherine Cooksey, "Manufacturing problem contest [invited]," Appl. Opt. 56, C1-C10 (2017).

Appendix A – Downloading filter specification and submitting data

An Excel file (*OIC 2019 Manufacturing Problem.xls*) is provided for participants to download the transmittance targets and includes a template for submitting their index profile and measured transmittance data. When submitting data, please add the last name of the first investigator to the above file name; for example, '*OIC 2019 Manufacturing Problem Contest Doe.xlsx*'.

The transmittance targets are also listed below, along with the index profile and measured transmittance data formats.

(a) Transmittance targets

Transmittance target (s-pol, at 10° AOI) for the 2019 OIC Manufacturing Problem

i	Wave (nm)	Target T10iD	Tol. ΔT10iD	i	Wave (nm)	Target T10iD	Tol. ΔT10iD	i	Wave (nm)	Target T10iD	Tol. ΔT10iD
1	450.0	0.7507	0.01	53	502.0	0.6626	0.01	105	554.0	0.5606	0.01
2	451.0	0.7495	0.01	54	503.0	0.6609	0.01	106	555.0	0.5587	0.01
3	452.0	0.7484	0.01	55	504.0	0.6591	0.01	107	556.0	0.5568	0.01
4	453.0	0.7472	0.01	56	505.0	0.6572	0.01	108	557.0	0.5550	0.01
5	454.0	0.7460	0.01	57	506.0	0.6552	0.01	109	558.0	0.5531	0.01
6	455.0	0.7449	0.01	58	507.0	0.6532	0.01	110	559.0	0.5512	0.01
7	456.0	0.7437	0.01	59	508.0	0.6513	0.01	111	560.0	0.5491	0.01
8	457.0	0.7425	0.01	60	509.0	0.6493	0.01	112	561.0	0.5466	0.01
9	458.0	0.7414	0.01	61	510.0	0.6473	0.01	113	562.0	0.5442	0.01
10	459.0	0.7402	0.01	62	511.0	0.6454	0.01	114	563.0	0.5417	0.01
11	460.0	0.7386	0.01	63	512.0	0.6436	0.01	115	564.0	0.5393	0.01
12	461.0	0.7369	0.01	64	513.0	0.6419	0.01	116	565.0	0.5368	0.01
13	462.0	0.7353	0.01	65	514.0	0.6403	0.01	117	566.0	0.5344	0.01
14	463.0	0.7337	0.01	66	515.0	0.6387	0.01	118	567.0	0.5322	0.01
15	464.0	0.7320	0.01	67	516.0	0.6370	0.01	119	568.0	0.5299	0.01
16	465.0	0.7304	0.01	68	517.0	0.6354	0.01	120	569.0	0.5277	0.01
17	466.0	0.7288	0.01	69	518.0	0.6338	0.01	121	570.0	0.5254	0.01
18	467.0	0.7271	0.01	70	519.0	0.6321	0.01	122	571.0	0.5232	0.01
19	468.0	0.7255	0.01	71	520.0	0.6305	0.01	123	572.0	0.5210	0.01
20	469.0	0.7237	0.01	72	521.0	0.6288	0.01	124	573.0	0.5187	0.01
21	470.0	0.7217	0.01	73	522.0	0.6272	0.01	125	574.0	0.5165	0.01
22	471.0	0.7198	0.01	74	523.0	0.6255	0.01	126	575.0	0.5142	0.01
23	472.0	0.7178	0.01	75	524.0	0.6238	0.01	127	576.0	0.5120	0.01
24	473.0	0.7159	0.01	76	525.0	0.6221	0.01	128	577.0	0.5098	0.01
25	474.0	0.7139	0.01	77	526.0	0.6205	0.01	129	578.0	0.5075	0.01
26	475.0	0.7119	0.01	78	527.0	0.6188	0.01	130	579.0	0.5053	0.01
27	476.0	0.7100	0.01	79	528.0	0.6171	0.01	131	580.0	0.5030	0.01
28	477.0	0.7083	0.01	80	529.0	0.6154	0.01	132	581.0	0.5008	0.01
29	478.0	0.7069	0.01	81	530.0	0.6131	0.01	133	582.0	0.4987	0.01
30	479.0	0.7055	0.01	82	531.0	0.6106	0.01	134	583.0	0.4969	0.01
31	480.0	0.7041	0.01	83	532.0	0.6082	0.01	135	584.0	0.4951	0.01
32	481.0	0.7027	0.01	84	533.0	0.6057	0.01	136	585.0	0.4933	0.01
33	482.0	0.7013	0.01	85	534.0	0.6033	0.01	137	586.0	0.4915	0.01
34	483.0	0.6999	0.01	86	535.0	0.6008	0.01	138	587.0	0.4896	0.01
35	484.0	0.6985	0.01	87	536.0	0.5987	0.01	139	588.0	0.4878	0.01
36	485.0	0.6971	0.01	88	537.0	0.5971	0.01	140	589.0	0.4860	0.01
37	486.0	0.6957	0.01	89	538.0	0.5954	0.01	141	590.0	0.4842	0.01
38	487.0	0.6934	0.01	90	539.0	0.5937	0.01	142	591.0	0.4824	0.01
39	488.0	0.6911	0.01	91	540.0	0.5920	0.01	143	592.0	0.4806	0.01
40	489.0	0.6888	0.01	92	541.0	0.5903	0.01	144	593.0	0.4789	0.01
41	490.0	0.6864	0.01	93	542.0	0.5887	0.01	145	594.0	0.4772	0.01
42	491.0	0.6841	0.01	94	543.0	0.5870	0.01	146	595.0	0.4756	0.01
43	492.0	0.6818	0.01	95	544.0	0.5847	0.01	147	596.0	0.4740	0.01
44	493.0	0.6794	0.01	96	545.0	0.5819	0.01	148	597.0	0.4723	0.01
45	494.0	0.6771	0.01	97	546.0	0.5791	0.01	149	598.0	0.4707	0.01
46	495.0	0.6748	0.01	98	547.0	0.5763	0.01	150	599.0	0.4691	0.01
47	496.0	0.6727	0.01	99	548.0	0.5735	0.01	151	600.0	0.4674	0.01
48	497.0	0.6710	0.01	100	549.0	0.5707	0.01	152	601.0	0.4658	0.01
49	498.0	0.6693	0.01	101	550.0	0.5681	0.01	153	602.0	0.4642	0.01
50	499.0	0.6676	0.01	102	551.0	0.5662	0.01	154	603.0	0.4623	0.01
51	500.0	0.6659	0.01	103	552.0	0.5643	0.01	155	604.0	0.4602	0.01
52	501.0	0.6643	0.01	104	553.0	0.5625	0.01	156	605.0	0.4581	0.01

Transmittance target (s-pol, at 10° AOI) for the 2019 OIC Manufacturing Problem (cont.)

i	Wave (nm)	Target T10iD	Tol. ΔT10iD	i	Wave (nm)	Target T10iD	Tol. ΔT10iD	i	Wave (nm)	Target T10iD	Tol. ΔT10iD
157	606.0	0.4560	0.01	209	658.0	0.3663	0.01	261	710.0	0.2638	0.01
158	607.0	0.4539	0.01	210	659.0	0.3645	0.01	262	711.0	0.2618	0.01
159	608.0	0.4518	0.01	211	660.0	0.3627	0.01	263	712.0	0.2598	0.01
160	609.0	0.4497	0.01	212	661.0	0.3608	0.01	264	713.0	0.2579	0.01
161	610.0	0.4477	0.01	213	662.0	0.3589	0.01	265	714.0	0.2559	0.01
162	611.0	0.4458	0.01	214	663.0	0.3571	0.01	266	715.0	0.2535	0.01
163	612.0	0.4438	0.01	215	664.0	0.3552	0.01	267	716.0	0.2509	0.01
164	613.0	0.4419	0.01	216	665.0	0.3533	0.01	268	717.0	0.2484	0.01
165	614.0	0.4399	0.01	217	666.0	0.3515	0.01	269	718.0	0.2459	0.01
166	615.0	0.4379	0.01	218	667.0	0.3496	0.01	270	719.0	0.2434	0.01
167	616.0	0.4360	0.01	219	668.0	0.3477	0.01	271	720.0	0.2409	0.01
168	617.0	0.4341	0.01	220	669.0	0.3459	0.01	272	721.0	0.2383	0.01
169	618.0	0.4327	0.01	221	670.0	0.3440	0.01	273	722.0	0.2358	0.01
170	619.0	0.4313	0.01	222	671.0	0.3421	0.01	274	723.0	0.2341	0.01
171	620.0	0.4299	0.01	223	672.0	0.3403	0.01	275	724.0	0.2325	0.01
172	621.0	0.4285	0.01	224	673.0	0.3384	0.01	276	725.0	0.2308	0.01
173	622.0	0.4271	0.01	225	674.0	0.3365	0.01	277	726.0	0.2292	0.01
174	623.0	0.4257	0.01	226	675.0	0.3345	0.01	278	727.0	0.2276	0.01
175	624.0	0.4243	0.01	227	676.0	0.3324	0.01	279	728.0	0.2259	0.01
176	625.0	0.4229	0.01	228	677.0	0.3303	0.01	280	729.0	0.2243	0.01
177	626.0	0.4215	0.01	229	678.0	0.3282	0.01	281	730.0	0.2227	0.01
178	627.0	0.4198	0.01	230	679.0	0.3261	0.01	282	731.0	0.2210	0.01
179	628.0	0.4180	0.01	231	680.0	0.3240	0.01	283	732.0	0.2194	0.01
180	629.0	0.4161	0.01	232	681.0	0.3219	0.01	284	733.0	0.2178	0.01
181	630.0	0.4142	0.01	233	682.0	0.3198	0.01	285	734.0	0.2161	0.01
182	631.0	0.4124	0.01	234	683.0	0.3177	0.01	286	735.0	0.2145	0.01
183	632.0	0.4105	0.01	235	684.0	0.3156	0.01	287	736.0	0.2129	0.01
184	633.0	0.4086	0.01	236	685.0	0.3135	0.01	288	737.0	0.2112	0.01
185	634.0	0.4068	0.01	237	686.0	0.3114	0.01	289	738.0	0.2096	0.01
186	635.0	0.4049	0.01	238	687.0	0.3093	0.01	290	739.0	0.2080	0.01
187	636.0	0.4030	0.01	239	688.0	0.3075	0.01	291	740.0	0.2063	0.01
188	637.0	0.4014	0.01	240	689.0	0.3057	0.01	292	741.0	0.2047	0.01
189	638.0	0.3999	0.01	241	690.0	0.3039	0.01	293	742.0	0.2022	0.01
190	639.0	0.3983	0.01	242	691.0	0.3021	0.01	294	743.0	0.1994	0.01
191	640.0	0.3967	0.01	243	692.0	0.3003	0.01	295	744.0	0.1966	0.01
192	641.0	0.3951	0.01	244	693.0	0.2985	0.01	296	745.0	0.1938	0.01
193	642.0	0.3936	0.01	245	694.0	0.2967	0.01	297	746.0	0.1910	0.01
194	643.0	0.3920	0.01	246	695.0	0.2949	0.01	298	747.0	0.1882	0.01
195	644.0	0.3904	0.01	247	696.0	0.2931	0.01	299	748.0	0.1856	0.01
196	645.0	0.3888	0.01	248	697.0	0.2913	0.01	300	749.0	0.1835	0.01
197	646.0	0.3873	0.01	249	698.0	0.2895	0.01	301	750.0	0.1814	0.01
198	647.0	0.3857	0.01	250	699.0	0.2873	0.01	302	751.0	0.1793	0.01
199	648.0	0.3841	0.01	251	700.0	0.2851	0.01	303	752.0	0.1772	0.01
200	649.0	0.3825	0.01	252	701.0	0.2828	0.01	304	753.0	0.1751	0.01
201	650.0	0.3807	0.01	253	702.0	0.2806	0.01	305	754.0	0.1730	0.01
202	651.0	0.3789	0.01	254	703.0	0.2784	0.01	306	755.0	0.1709	0.01
203	652.0	0.3771	0.01	255	704.0	0.2761	0.01	307	756.0	0.1688	0.01
204	653.0	0.3753	0.01	256	705.0	0.2739	0.01	308	757.0	0.1667	0.01
205	654.0	0.3735	0.01	257	706.0	0.2716	0.01	309	758.0	0.1643	0.01
206	655.0	0.3717	0.01	258	707.0	0.2696	0.01	310	759.0	0.1619	0.01
207	656.0	0.3699	0.01	259	708.0	0.2677	0.01	311	760.0	0.1594	0.01
208	657.0	0.3681	0.01	260	709.0	0.2657	0.01	312	761.0	0.1570	0.01

Transmittance target (s-pol, at 10° AOI) for the 2019 OIC Manufacturing Problem (cont.)

i	Wave (nm)	Target T10iD	Tol. ΔT10iD	i	Wave (nm)	Target T10iD	Tol. ΔT10iD	i	Wave (nm)	Target T10iD	Tol. ΔT10iD
313	762.0	0.1545	0.01	365	814.0	0.2508	0.01	417	866.0	0.4069	0.01
314	763.0	0.1521	0.01	366	815.0	0.2552	0.01	418	867.0	0.4095	0.01
315	764.0	0.1479	0.01	367	816.0	0.2599	0.01	419	868.0	0.4121	0.01
316	765.0	0.1416	0.01	368	817.0	0.2646	0.01	420	869.0	0.4147	0.01
317	766.0	0.1353	0.01	369	818.0	0.2692	0.01	421	870.0	0.4173	0.01
318	767.0	0.1309	0.01	370	819.0	0.2739	0.01	422	871.0	0.4196	0.01
319	768.0	0.1318	0.01	371	820.0	0.2777	0.01	423	872.0	0.4217	0.01
320	769.0	0.1328	0.01	372	821.0	0.2811	0.01	424	873.0	0.4238	0.01
321	770.0	0.1337	0.01	373	822.0	0.2844	0.01	425	874.0	0.4259	0.01
322	771.0	0.1346	0.01	374	823.0	0.2878	0.01	426	875.0	0.4280	0.01
323	772.0	0.1355	0.01	375	824.0	0.2911	0.01	427	876.0	0.4300	0.01
324	773.0	0.1365	0.01	376	825.0	0.2945	0.01	428	877.0	0.4321	0.01
325	774.0	0.1374	0.01	377	826.0	0.2979	0.01	429	878.0	0.4342	0.01
326	775.0	0.1383	0.01	378	827.0	0.3012	0.01	430	879.0	0.4363	0.01
327	776.0	0.1393	0.01	379	828.0	0.3039	0.01	431	880.0	0.4385	0.01
328	777.0	0.1412	0.01	380	829.0	0.3063	0.01	432	881.0	0.4413	0.01
329	778.0	0.1437	0.01	381	830.0	0.3087	0.01	433	882.0	0.4441	0.01
330	779.0	0.1461	0.01	382	831.0	0.3111	0.01	434	883.0	0.4469	0.01
331	780.0	0.1486	0.01	383	832.0	0.3135	0.01	435	884.0	0.4497	0.01
332	781.0	0.1510	0.01	384	833.0	0.3159	0.01	436	885.0	0.4525	0.01
333	782.0	0.1535	0.01	385	834.0	0.3183	0.01	437	886.0	0.4553	0.01
334	783.0	0.1563	0.01	386	835.0	0.3207	0.01	438	887.0	0.4580	0.01
335	784.0	0.1601	0.01	387	836.0	0.3231	0.01	439	888.0	0.4608	0.01
336	785.0	0.1638	0.01	388	837.0	0.3255	0.01	440	889.0	0.4636	0.01
337	786.0	0.1675	0.01	389	838.0	0.3279	0.01	441	890.0	0.4662	0.01
338	787.0	0.1712	0.01	390	839.0	0.3306	0.01	442	891.0	0.4685	0.01
339	788.0	0.1745	0.01	391	840.0	0.3336	0.01	443	892.0	0.4709	0.01
340	789.0	0.1773	0.01	392	841.0	0.3366	0.01	444	893.0	0.4732	0.01
341	790.0	0.1801	0.01	393	842.0	0.3396	0.01	445	894.0	0.4755	0.01
342	791.0	0.1829	0.01	394	843.0	0.3426	0.01	446	895.0	0.4779	0.01
343	792.0	0.1857	0.01	395	844.0	0.3456	0.01	447	896.0	0.4802	0.01
344	793.0	0.1885	0.01	396	845.0	0.3486	0.01	448	897.0	0.4825	0.01
345	794.0	0.1913	0.01	397	846.0	0.3516	0.01	449	898.0	0.4849	0.01
346	795.0	0.1941	0.01	398	847.0	0.3546	0.01	450	899.0	0.4872	0.01
347	796.0	0.1976	0.01	399	848.0	0.3576	0.01	451	900.0	0.4895	0.01
348	797.0	0.2018	0.01	400	849.0	0.3606	0.01	452	901.0	0.4918	0.01
349	798.0	0.2060	0.01	401	850.0	0.3635	0.01	453	902.0	0.4942	0.01
350	799.0	0.2102	0.01	402	851.0	0.3663	0.01	454	903.0	0.4965	0.01
351	800.0	0.2144	0.01	403	852.0	0.3691	0.01	455	904.0	0.4988	0.01
352	801.0	0.2168	0.01	404	853.0	0.3719	0.01	456	905.0	0.5009	0.01
353	802.0	0.2187	0.01	405	854.0	0.3747	0.01	457	906.0	0.5030	0.01
354	803.0	0.2205	0.01	406	855.0	0.3775	0.01	458	907.0	0.5051	0.01
355	804.0	0.2224	0.01	407	856.0	0.3803	0.01	459	908.0	0.5072	0.01
356	805.0	0.2243	0.01	408	857.0	0.3831	0.01	460	909.0	0.5093	0.01
357	806.0	0.2261	0.01	409	858.0	0.3859	0.01	461	910.0	0.5114	0.01
358	807.0	0.2280	0.01	410	859.0	0.3887	0.01	462	911.0	0.5135	0.01
359	808.0	0.2299	0.01	411	860.0	0.3913	0.01	463	912.0	0.5156	0.01
360	809.0	0.2317	0.01	412	861.0	0.3939	0.01	464	913.0	0.5177	0.01
361	810.0	0.2341	0.01	413	862.0	0.3965	0.01	465	914.0	0.5198	0.01
362	811.0	0.2383	0.01	414	863.0	0.3991	0.01	466	915.0	0.5219	0.01
363	812.0	0.2425	0.01	415	864.0	0.4017	0.01	467	916.0	0.5240	0.01
364	813.0	0.2467	0.01	416	865.0	0.4043	0.01	468	917.0	0.5260	0.01

Transmittance target (s-pol, at 10° AOI) for the 2019 OIC Manufacturing Problem (cont.)

i	Wave (nm)	Target T10iD	Tol. ΔT10iD	i	Wave (nm)	Target T10iD	Tol. ΔT10iD	i	Wave (nm)	Target T10iD	Tol. ΔT10iD
469	918.0	0.5280	0.01	521	970.0	0.6248	0.01	573	1022.0	0.7157	0.01
470	919.0	0.5300	0.01	522	971.0	0.6266	0.01	574	1023.0	0.7173	0.01
471	920.0	0.5320	0.01	523	972.0	0.6285	0.01	575	1024.0	0.7188	0.01
472	921.0	0.5340	0.01	524	973.0	0.6304	0.01	576	1025.0	0.7204	0.01
473	922.0	0.5360	0.01	525	974.0	0.6322	0.01	577	1026.0	0.7219	0.01
474	923.0	0.5380	0.01	526	975.0	0.6341	0.01	578	1027.0	0.7235	0.01
475	924.0	0.5400	0.01	527	976.0	0.6360	0.01	579	1028.0	0.7250	0.01
476	925.0	0.5420	0.01	528	977.0	0.6378	0.01	580	1029.0	0.7266	0.01
477	926.0	0.5440	0.01	529	978.0	0.6397	0.01	581	1030.0	0.7281	0.01
478	927.0	0.5460	0.01	530	979.0	0.6416	0.01	582	1031.0	0.7297	0.01
479	928.0	0.5480	0.01	531	980.0	0.6437	0.01	583	1032.0	0.7313	0.01
480	929.0	0.5497	0.01	532	981.0	0.6458	0.01	584	1033.0	0.7329	0.01
481	930.0	0.5514	0.01	533	982.0	0.6479	0.01	585	1034.0	0.7345	0.01
482	931.0	0.5532	0.01	534	983.0	0.6500	0.01	586	1035.0	0.7362	0.01
483	932.0	0.5549	0.01	535	984.0	0.6521	0.01	587	1036.0	0.7378	0.01
484	933.0	0.5567	0.01	536	985.0	0.6542	0.01	588	1037.0	0.7394	0.01
485	934.0	0.5584	0.01	537	986.0	0.6563	0.01	589	1038.0	0.7411	0.01
486	935.0	0.5602	0.01	538	987.0	0.6584	0.01	590	1039.0	0.7427	0.01
487	936.0	0.5619	0.01	539	988.0	0.6605	0.01	591	1040.0	0.7443	0.01
488	937.0	0.5637	0.01	540	989.0	0.6626	0.01	592	1041.0	0.7460	0.01
489	938.0	0.5654	0.01	541	990.0	0.6647	0.01	593	1042.0	0.7474	0.01
490	939.0	0.5672	0.01	542	991.0	0.6668	0.01	594	1043.0	0.7488	0.01
491	940.0	0.5689	0.01	543	992.0	0.6686	0.01	595	1044.0	0.7501	0.01
492	941.0	0.5708	0.01	544	993.0	0.6702	0.01	596	1045.0	0.7515	0.01
493	942.0	0.5729	0.01	545	994.0	0.6718	0.01	597	1046.0	0.7529	0.01
494	943.0	0.5750	0.01	546	995.0	0.6733	0.01	598	1047.0	0.7543	0.01
495	944.0	0.5771	0.01	547	996.0	0.6749	0.01	599	1048.0	0.7557	0.01
496	945.0	0.5792	0.01	548	997.0	0.6765	0.01	600	1049.0	0.7571	0.01
497	946.0	0.5813	0.01	549	998.0	0.6781	0.01	601	1050.0	0.7585	0.01
498	947.0	0.5834	0.01	550	999.0	0.6796	0.01	602	1051.0	0.7599	0.01
499	948.0	0.5855	0.01	551	1000.0	0.6812	0.01	603	1052.0	0.7613	0.01
500	949.0	0.5876	0.01	552	1001.0	0.6828	0.01	604	1053.0	0.7629	0.01
501	950.0	0.5897	0.01	553	1002.0	0.6844	0.01	605	1054.0	0.7645	0.01
502	951.0	0.5915	0.01	554	1003.0	0.6859	0.01	606	1055.0	0.7661	0.01
503	952.0	0.5932	0.01	555	1004.0	0.6875	0.01	607	1056.0	0.7677	0.01
504	953.0	0.5949	0.01	556	1005.0	0.6891	0.01	608	1057.0	0.7693	0.01
505	954.0	0.5966	0.01	557	1006.0	0.6906	0.01	609	1058.0	0.7709	0.01
506	955.0	0.5983	0.01	558	1007.0	0.6922	0.01	610	1059.0	0.7725	0.01
507	956.0	0.6000	0.01	559	1008.0	0.6938	0.01	611	1060.0	0.7741	0.01
508	957.0	0.6017	0.01	560	1009.0	0.6954	0.01	612	1061.0	0.7757	0.01
509	958.0	0.6034	0.01	561	1010.0	0.6969	0.01	613	1062.0	0.7773	0.01
510	959.0	0.6051	0.01	562	1011.0	0.6985	0.01	614	1063.0	0.7789	0.01
511	960.0	0.6068	0.01	563	1012.0	0.7001	0.01	615	1064.0	0.7803	0.01
512	961.0	0.6085	0.01	564	1013.0	0.7016	0.01	616	1065.0	0.7817	0.01
513	962.0	0.6102	0.01	565	1014.0	0.7032	0.01	617	1066.0	0.7831	0.01
514	963.0	0.6120	0.01	566	1015.0	0.7048	0.01	618	1067.0	0.7845	0.01
515	964.0	0.6137	0.01	567	1016.0	0.7064	0.01	619	1068.0	0.7859	0.01
516	965.0	0.6155	0.01	568	1017.0	0.7079	0.01	620	1069.0	0.7873	0.01
517	966.0	0.6173	0.01	569	1018.0	0.7095	0.01	621	1070.0	0.7887	0.01
518	967.0	0.6192	0.01	570	1019.0	0.7110	0.01	622	1071.0	0.7901	0.01
519	968.0	0.6210	0.01	571	1020.0	0.7126	0.01	623	1072.0	0.7915	0.01
520	969.0	0.6229	0.01	572	1021.0	0.7142	0.01	624	1073.0	0.7929	0.01
								625	1074.0	0.7943	0.01
								626	1075.0	0.7957	0.01

Transmittance target (s-pol, at 50° AOI) for the 2019 OIC Manufacturing Problem

i	Wave (nm)	Target T50iD	Tol. ΔT50iD	i	Wave (nm)	Target T50iD	Tol. ΔT50iD	i	Wave (nm)	Target T50iD	Tol. ΔT50iD
1	480.0	0.3233	0.01	53	532.0	0.2957	0.01	105	584.0	0.2697	0.01
2	481.0	0.3231	0.01	54	533.0	0.2952	0.01	106	585.0	0.2692	0.01
3	482.0	0.3226	0.01	55	534.0	0.2947	0.01	107	586.0	0.2688	0.01
4	483.0	0.3222	0.01	56	535.0	0.2942	0.01	108	587.0	0.2683	0.01
5	484.0	0.3217	0.01	57	536.0	0.2937	0.01	109	588.0	0.2678	0.01
6	485.0	0.3212	0.01	58	537.0	0.2932	0.01	110	589.0	0.2674	0.01
7	486.0	0.3208	0.01	59	538.0	0.2927	0.01	111	590.0	0.2668	0.01
8	487.0	0.3203	0.01	60	539.0	0.2923	0.01	112	591.0	0.2660	0.01
9	488.0	0.3198	0.01	61	540.0	0.2918	0.01	113	592.0	0.2652	0.01
10	489.0	0.3194	0.01	62	541.0	0.2913	0.01	114	593.0	0.2644	0.01
11	490.0	0.3189	0.01	63	542.0	0.2909	0.01	115	594.0	0.2636	0.01
12	491.0	0.3184	0.01	64	543.0	0.2904	0.01	116	595.0	0.2628	0.01
13	492.0	0.3180	0.01	65	544.0	0.2899	0.01	117	596.0	0.2620	0.01
14	493.0	0.3175	0.01	66	545.0	0.2894	0.01	118	597.0	0.2612	0.01
15	494.0	0.3170	0.01	67	546.0	0.2890	0.01	119	598.0	0.2604	0.01
16	495.0	0.3166	0.01	68	547.0	0.2885	0.01	120	599.0	0.2596	0.01
17	496.0	0.3161	0.01	69	548.0	0.2880	0.01	121	600.0	0.2588	0.01
18	497.0	0.3156	0.01	70	549.0	0.2876	0.01	122	601.0	0.2580	0.01
19	498.0	0.3150	0.01	71	550.0	0.2871	0.01	123	602.0	0.2571	0.01
20	499.0	0.3145	0.01	72	551.0	0.2866	0.01	124	603.0	0.2562	0.01
21	500.0	0.3140	0.01	73	552.0	0.2861	0.01	125	604.0	0.2554	0.01
22	501.0	0.3134	0.01	74	553.0	0.2855	0.01	126	605.0	0.2545	0.01
23	502.0	0.3129	0.01	75	554.0	0.2850	0.01	127	606.0	0.2536	0.01
24	503.0	0.3124	0.01	76	555.0	0.2845	0.01	128	607.0	0.2527	0.01
25	504.0	0.3119	0.01	77	556.0	0.2839	0.01	129	608.0	0.2519	0.01
26	505.0	0.3113	0.01	78	557.0	0.2834	0.01	130	609.0	0.2510	0.01
27	506.0	0.3108	0.01	79	558.0	0.2829	0.01	131	610.0	0.2501	0.01
28	507.0	0.3103	0.01	80	559.0	0.2824	0.01	132	611.0	0.2492	0.01
29	508.0	0.3098	0.01	81	560.0	0.2818	0.01	133	612.0	0.2484	0.01
30	509.0	0.3092	0.01	82	561.0	0.2813	0.01	134	613.0	0.2475	0.01
31	510.0	0.3086	0.01	83	562.0	0.2808	0.01	135	614.0	0.2467	0.01
32	511.0	0.3079	0.01	84	563.0	0.2803	0.01	136	615.0	0.2460	0.01
33	512.0	0.3073	0.01	85	564.0	0.2797	0.01	137	616.0	0.2453	0.01
34	513.0	0.3067	0.01	86	565.0	0.2792	0.01	138	617.0	0.2446	0.01
35	514.0	0.3061	0.01	87	566.0	0.2787	0.01	139	618.0	0.2439	0.01
36	515.0	0.3054	0.01	88	567.0	0.2782	0.01	140	619.0	0.2432	0.01
37	516.0	0.3048	0.01	89	568.0	0.2776	0.01	141	620.0	0.2425	0.01
38	517.0	0.3042	0.01	90	569.0	0.2771	0.01	142	621.0	0.2418	0.01
39	518.0	0.3036	0.01	91	570.0	0.2766	0.01	143	622.0	0.2411	0.01
40	519.0	0.3029	0.01	92	571.0	0.2761	0.01	144	623.0	0.2404	0.01
41	520.0	0.3023	0.01	93	572.0	0.2755	0.01	145	624.0	0.2397	0.01
42	521.0	0.3017	0.01	94	573.0	0.2750	0.01	146	625.0	0.2390	0.01
43	522.0	0.3011	0.01	95	574.0	0.2745	0.01	147	626.0	0.2383	0.01
44	523.0	0.3005	0.01	96	575.0	0.2739	0.01	148	627.0	0.2376	0.01
45	524.0	0.2999	0.01	97	576.0	0.2735	0.01	149	628.0	0.2369	0.01
46	525.0	0.2994	0.01	98	577.0	0.2730	0.01	150	629.0	0.2362	0.01
47	526.0	0.2989	0.01	99	578.0	0.2725	0.01	151	630.0	0.2353	0.01
48	527.0	0.2984	0.01	100	579.0	0.2721	0.01	152	631.0	0.2342	0.01
49	528.0	0.2978	0.01	101	580.0	0.2716	0.01	153	632.0	0.2331	0.01
50	529.0	0.2973	0.01	102	581.0	0.2711	0.01	154	633.0	0.2320	0.01
51	530.0	0.2968	0.01	103	582.0	0.2706	0.01	155	634.0	0.2309	0.01
52	531.0	0.2963	0.01	104	583.0	0.2702	0.01	156	635.0	0.2299	0.01

Transmittance target (s-pol, at 50° AOI) for the 2019 OIC Manufacturing Problem (cont.)

i	Wave (nm)	Target T50iD	Tol. ΔT50iD	i	Wave (nm)	Target T50iD	Tol. ΔT50iD	i	Wave (nm)	Target T50iD	Tol. ΔT50iD
157	636.0	0.2288	0.01	209	688.0	0.1855	0.01	261	740.0	0.1306	0.01
158	637.0	0.2277	0.01	210	689.0	0.1844	0.01	262	741.0	0.1289	0.01
159	638.0	0.2266	0.01	211	690.0	0.1833	0.01	263	742.0	0.1274	0.01
160	639.0	0.2255	0.01	212	691.0	0.1822	0.01	264	743.0	0.1260	0.01
161	640.0	0.2244	0.01	213	692.0	0.1811	0.01	265	744.0	0.1246	0.01
162	641.0	0.2233	0.01	214	693.0	0.1800	0.01	266	745.0	0.1232	0.01
163	642.0	0.2222	0.01	215	694.0	0.1789	0.01	267	746.0	0.1218	0.01
164	643.0	0.2211	0.01	216	695.0	0.1778	0.01	268	747.0	0.1204	0.01
165	644.0	0.2201	0.01	217	696.0	0.1768	0.01	269	748.0	0.1190	0.01
166	645.0	0.2193	0.01	218	697.0	0.1757	0.01	270	749.0	0.1176	0.01
167	646.0	0.2185	0.01	219	698.0	0.1746	0.01	271	750.0	0.1170	0.01
168	647.0	0.2177	0.01	220	699.0	0.1735	0.01	272	751.0	0.1166	0.01
169	648.0	0.2169	0.01	221	700.0	0.1724	0.01	273	752.0	0.1162	0.01
170	649.0	0.2162	0.01	222	701.0	0.1713	0.01	274	753.0	0.1158	0.01
171	650.0	0.2154	0.01	223	702.0	0.1704	0.01	275	754.0	0.1154	0.01
172	651.0	0.2146	0.01	224	703.0	0.1696	0.01	276	755.0	0.1150	0.01
173	652.0	0.2138	0.01	225	704.0	0.1689	0.01	277	756.0	0.1146	0.01
174	653.0	0.2130	0.01	226	705.0	0.1681	0.01	278	757.0	0.1142	0.01
175	654.0	0.2123	0.01	227	706.0	0.1673	0.01	279	758.0	0.1138	0.01
176	655.0	0.2115	0.01	228	707.0	0.1665	0.01	280	759.0	0.1134	0.01
177	656.0	0.2107	0.01	229	708.0	0.1657	0.01	281	760.0	0.1130	0.01
178	657.0	0.2099	0.01	230	709.0	0.1650	0.01	282	761.0	0.1128	0.01
179	658.0	0.2092	0.01	231	710.0	0.1642	0.01	283	762.0	0.1128	0.01
180	659.0	0.2083	0.01	232	711.0	0.1634	0.01	284	763.0	0.1128	0.01
181	660.0	0.2073	0.01	233	712.0	0.1626	0.01	285	764.0	0.1128	0.01
182	661.0	0.2064	0.01	234	713.0	0.1618	0.01	286	765.0	0.1128	0.01
183	662.0	0.2055	0.01	235	714.0	0.1611	0.01	287	766.0	0.1128	0.01
184	663.0	0.2045	0.01	236	715.0	0.1603	0.01	288	767.0	0.1128	0.01
185	664.0	0.2036	0.01	237	716.0	0.1595	0.01	289	768.0	0.1128	0.01
186	665.0	0.2027	0.01	238	717.0	0.1585	0.01	290	769.0	0.1128	0.01
187	666.0	0.2017	0.01	239	718.0	0.1576	0.01	291	770.0	0.1128	0.01
188	667.0	0.2008	0.01	240	719.0	0.1567	0.01	292	771.0	0.1128	0.01
189	668.0	0.1999	0.01	241	720.0	0.1557	0.01	293	772.0	0.1130	0.01
190	669.0	0.1989	0.01	242	721.0	0.1548	0.01	294	773.0	0.1135	0.01
191	670.0	0.1980	0.01	243	722.0	0.1539	0.01	295	774.0	0.1139	0.01
192	671.0	0.1971	0.01	244	723.0	0.1529	0.01	296	775.0	0.1144	0.01
193	672.0	0.1961	0.01	245	724.0	0.1520	0.01	297	776.0	0.1149	0.01
194	673.0	0.1953	0.01	246	725.0	0.1511	0.01	298	777.0	0.1153	0.01
195	674.0	0.1947	0.01	247	726.0	0.1500	0.01	299	778.0	0.1158	0.01
196	675.0	0.1940	0.01	248	727.0	0.1488	0.01	300	779.0	0.1163	0.01
197	676.0	0.1934	0.01	249	728.0	0.1476	0.01	301	780.0	0.1167	0.01
198	677.0	0.1928	0.01	250	729.0	0.1465	0.01	302	781.0	0.1172	0.01
199	678.0	0.1922	0.01	251	730.0	0.1453	0.01	303	782.0	0.1188	0.01
200	679.0	0.1915	0.01	252	731.0	0.1441	0.01	304	783.0	0.1206	0.01
201	680.0	0.1909	0.01	253	732.0	0.1430	0.01	305	784.0	0.1223	0.01
202	681.0	0.1903	0.01	254	733.0	0.1418	0.01	306	785.0	0.1241	0.01
203	682.0	0.1897	0.01	255	734.0	0.1406	0.01	307	786.0	0.1258	0.01
204	683.0	0.1891	0.01	256	735.0	0.1394	0.01	308	787.0	0.1276	0.01
205	684.0	0.1884	0.01	257	736.0	0.1376	0.01	309	788.0	0.1293	0.01
206	685.0	0.1878	0.01	258	737.0	0.1359	0.01	310	789.0	0.1309	0.01
207	686.0	0.1872	0.01	259	738.0	0.1341	0.01	311	790.0	0.1326	0.01
208	687.0	0.1866	0.01	260	739.0	0.1324	0.01	312	791.0	0.1343	0.01

	Transmittance target (s-pol, at 50° AOI) for the 2019 OIC Manufacturing Problem (cont.)										
i	Wave (nm)	Target T50iD	Tol. ΔT50iD	i	Wave (nm)	Target T50iD	Tol. ΔT50iD	i	Wave (nm)	Target T50iD	Tol. ΔT50iD
313	792.0	0.1360	0.01	365	844.0	0.1937	0.01	417	896.0	0.2383	0.01
314	793.0	0.1377	0.01	366	845.0	0.1946	0.01	418	897.0	0.2393	0.01
315	794.0	0.1393	0.01	367	846.0	0.1955	0.01	419	898.0	0.2402	0.01
316	795.0	0.1410	0.01	368	847.0	0.1965	0.01	420	899.0	0.2411	0.01
317	796.0	0.1425	0.01	369	848.0	0.1974	0.01	421	900.0	0.2419	0.01
318	797.0	0.1439	0.01	370	849.0	0.1983	0.01	422	901.0	0.2428	0.01
319	798.0	0.1453	0.01	371	850.0	0.1993	0.01	423	902.0	0.2437	0.01
320	799.0	0.1467	0.01	372	851.0	0.2002	0.01	424	903.0	0.2446	0.01
321	800.0	0.1481	0.01	373	852.0	0.2011	0.01	425	904.0	0.2454	0.01
322	801.0	0.1495	0.01	374	853.0	0.2020	0.01	426	905.0	0.2463	0.01
323	802.0	0.1509	0.01	375	854.0	0.2028	0.01	427	906.0	0.2472	0.01
324	803.0	0.1523	0.01	376	855.0	0.2036	0.01	428	907.0	0.2481	0.01
325	804.0	0.1537	0.01	377	856.0	0.2044	0.01	429	908.0	0.2489	0.01
326	805.0	0.1549	0.01	378	857.0	0.2052	0.01	430	909.0	0.2498	0.01
327	806.0	0.1561	0.01	379	858.0	0.2060	0.01	431	910.0	0.2507	0.01
328	807.0	0.1572	0.01	380	859.0	0.2068	0.01	432	911.0	0.2514	0.01
329	808.0	0.1583	0.01	381	860.0	0.2076	0.01	433	912.0	0.2521	0.01
330	809.0	0.1595	0.01	382	861.0	0.2084	0.01	434	913.0	0.2528	0.01
331	810.0	0.1606	0.01	383	862.0	0.2092	0.01	435	914.0	0.2535	0.01
332	811.0	0.1618	0.01	384	863.0	0.2100	0.01	436	915.0	0.2542	0.01
333	812.0	0.1629	0.01	385	864.0	0.2108	0.01	437	916.0	0.2549	0.01
334	813.0	0.1641	0.01	386	865.0	0.2118	0.01	438	917.0	0.2556	0.01
335	814.0	0.1652	0.01	387	866.0	0.2128	0.01	439	918.0	0.2563	0.01
336	815.0	0.1663	0.01	388	867.0	0.2138	0.01	440	919.0	0.2570	0.01
337	816.0	0.1674	0.01	389	868.0	0.2148	0.01	441	920.0	0.2577	0.01
338	817.0	0.1685	0.01	390	869.0	0.2158	0.01	442	921.0	0.2584	0.01
339	818.0	0.1696	0.01	391	870.0	0.2168	0.01	443	922.0	0.2591	0.01
340	819.0	0.1708	0.01	392	871.0	0.2178	0.01	444	923.0	0.2598	0.01
341	820.0	0.1719	0.01	393	872.0	0.2188	0.01	445	924.0	0.2603	0.01
342	821.0	0.1730	0.01	394	873.0	0.2198	0.01	446	925.0	0.2608	0.01
343	822.0	0.1738	0.01	395	874.0	0.2208	0.01	447	926.0	0.2614	0.01
344	823.0	0.1746	0.01	396	875.0	0.2218	0.01	448	927.0	0.2619	0.01
345	824.0	0.1754	0.01	397	876.0	0.2224	0.01	449	928.0	0.2624	0.01
346	825.0	0.1762	0.01	398	877.0	0.2230	0.01	450	929.0	0.2629	0.01
347	826.0	0.1770	0.01	399	878.0	0.2236	0.01	451	930.0	0.2635	0.01
348	827.0	0.1778	0.01	400	879.0	0.2242	0.01	452	931.0	0.2640	0.01
349	828.0	0.1786	0.01	401	880.0	0.2248	0.01	453	932.0	0.2645	0.01
350	829.0	0.1794	0.01	402	881.0	0.2254	0.01	454	933.0	0.2650	0.01
351	830.0	0.1802	0.01	403	882.0	0.2260	0.01	455	934.0	0.2655	0.01
352	831.0	0.1810	0.01	404	883.0	0.2266	0.01	456	935.0	0.2661	0.01
353	832.0	0.1818	0.01	405	884.0	0.2272	0.01	457	936.0	0.2666	0.01
354	833.0	0.1827	0.01	406	885.0	0.2278	0.01	458	937.0	0.2673	0.01
355	834.0	0.1837	0.01	407	886.0	0.2284	0.01	459	938.0	0.2680	0.01
356	835.0	0.1847	0.01	408	887.0	0.2293	0.01	460	939.0	0.2687	0.01
357	836.0	0.1857	0.01	409	888.0	0.2303	0.01	461	940.0	0.2694	0.01
358	837.0	0.1867	0.01	410	889.0	0.2313	0.01	462	941.0	0.2701	0.01
359	838.0	0.1877	0.01	411	890.0	0.2323	0.01	463	942.0	0.2708	0.01
360	839.0	0.1887	0.01	412	891.0	0.2333	0.01	464	943.0	0.2715	0.01
361	840.0	0.1897	0.01	413	892.0	0.2343	0.01	465	944.0	0.2722	0.01
362	841.0	0.1907	0.01	414	893.0	0.2353	0.01	466	945.0	0.2729	0.01
363	842.0	0.1917	0.01	415	894.0	0.2363	0.01	467	946.0	0.2736	0.01
364	843.0	0.1927	0.01	416	895.0	0.2373	0.01	468	947.0	0.2743	0.01

Transmittance target (s-pol, at 50° AOI) for the 2019 OIC Manufacturing Problem (cont.)

i	Wave (nm)	Target T50iD	Tol. ΔT50iD	i	Wave (nm)	Target T50iD	Tol. ΔT50iD	i	Wave (nm)	Target T50iD	Tol. ΔT50iD
469	948.0	0.2750	0.01	521	1000.0	0.3076	0.01	573	1052.0	0.3327	0.01
470	949.0	0.2756	0.01	522	1001.0	0.3081	0.01	574	1053.0	0.3332	0.01
471	950.0	0.2761	0.01	523	1002.0	0.3086	0.01	575	1054.0	0.3336	0.01
472	951.0	0.2767	0.01	524	1003.0	0.3092	0.01	576	1055.0	0.3340	0.01
473	952.0	0.2772	0.01	525	1004.0	0.3097	0.01	577	1056.0	0.3345	0.01
474	953.0	0.2777	0.01	526	1005.0	0.3102	0.01	578	1057.0	0.3349	0.01
475	954.0	0.2782	0.01	527	1006.0	0.3107	0.01	579	1058.0	0.3353	0.01
476	955.0	0.2788	0.01	528	1007.0	0.3113	0.01	580	1059.0	0.3358	0.01
477	956.0	0.2793	0.01	529	1008.0	0.3118	0.01	581	1060.0	0.3362	0.01
478	957.0	0.2798	0.01	530	1009.0	0.3123	0.01	582	1061.0	0.3366	0.01
479	958.0	0.2803	0.01	531	1010.0	0.3128	0.01	583	1062.0	0.3371	0.01
480	959.0	0.2809	0.01	532	1011.0	0.3134	0.01	584	1063.0	0.3375	0.01
481	960.0	0.2814	0.01	533	1012.0	0.3139	0.01	585	1064.0	0.3379	0.01
482	961.0	0.2819	0.01	534	1013.0	0.3144	0.01	586	1065.0	0.3384	0.01
483	962.0	0.2826	0.01	535	1014.0	0.3149	0.01				
484	963.0	0.2832	0.01	536	1015.0	0.3154	0.01				
485	964.0	0.2839	0.01	537	1016.0	0.3160	0.01				
486	965.0	0.2846	0.01	538	1017.0	0.3165	0.01				
487	966.0	0.2853	0.01	539	1018.0	0.3170	0.01				
488	967.0	0.2860	0.01	540	1019.0	0.3175	0.01				
489	968.0	0.2867	0.01	541	1020.0	0.3181	0.01				
490	969.0	0.2874	0.01	542	1021.0	0.3186	0.01				
491	970.0	0.2881	0.01	543	1022.0	0.3191	0.01				
492	971.0	0.2888	0.01	544	1023.0	0.3196	0.01				
493	972.0	0.2895	0.01	545	1024.0	0.3202	0.01				
494	973.0	0.2902	0.01	546	1025.0	0.3208	0.01				
495	974.0	0.2909	0.01	547	1026.0	0.3214	0.01				
496	975.0	0.2915	0.01	548	1027.0	0.3221	0.01				
497	976.0	0.2920	0.01	549	1028.0	0.3227	0.01				
498	977.0	0.2925	0.01	550	1029.0	0.3233	0.01				
499	978.0	0.2930	0.01	551	1030.0	0.3239	0.01				
500	979.0	0.2935	0.01	552	1031.0	0.3245	0.01				
501	980.0	0.2941	0.01	553	1032.0	0.3252	0.01				
502	981.0	0.2946	0.01	554	1033.0	0.3258	0.01				
503	982.0	0.2951	0.01	555	1034.0	0.3264	0.01				
504	983.0	0.2956	0.01	556	1035.0	0.3270	0.01				
505	984.0	0.2962	0.01	557	1036.0	0.3276	0.01				
506	985.0	0.2967	0.01	558	1037.0	0.3283	0.01				
507	986.0	0.2972	0.01	559	1038.0	0.3288	0.01				
508	987.0	0.2978	0.01	560	1039.0	0.3291	0.01				
509	988.0	0.2986	0.01	561	1040.0	0.3293	0.01				
510	989.0	0.2994	0.01	562	1041.0	0.3296	0.01				
511	990.0	0.3002	0.01	563	1042.0	0.3299	0.01				
512	991.0	0.3010	0.01	564	1043.0	0.3301	0.01				
513	992.0	0.3018	0.01	565	1044.0	0.3304	0.01				
514	993.0	0.3026	0.01	566	1045.0	0.3306	0.01				
515	994.0	0.3034	0.01	567	1046.0	0.3309	0.01				
516	995.0	0.3042	0.01	568	1047.0	0.3312	0.01				
517	996.0	0.3050	0.01	569	1048.0	0.3314	0.01				
518	997.0	0.3058	0.01	570	1049.0	0.3317	0.01				
519	998.0	0.3066	0.01	571	1050.0	0.3320	0.01				
520	999.0	0.3071	0.01	572	1051.0	0.3323	0.01				

(b) Refractive index profile of submitted sample

Participant name(s): John Doe, …
Affiliation name: XYZ. Inc
Contact person address: 1234 Farmers Lane, Eureka CA 95472 USA
Contact person email: JDoe@XYZ.com
Sample description: Doe 1
Total physical thickness Σd (nm): 3500.00
Design calculated merit function *MF*: 1.0000
Sample measured merit function *MF*: 3.0000

Design Index Profile			
Layer Number	Refractive Index *n* at 750 nm	Extinction Coefficient *k* at 750 nm	Physical thickness *d* (nm)
Incident medium Air	**1.000**	**0.000**	**-**
m	**1.460**	**0.000**	**43.21**
.	**.**	**.**	**.**
.	**.**	**.**	**.**
.	**.**	**.**	**.**
3	**2.450**	**0.000**	**123.45**
2	**1.460**	**0.000**	**250.20**
1	**0.200**	**1.230**	**10.58**
Substrate N-BK7	**1.520**	**0.000**	**-**
1	**2.450**	**0.000**	**250.00**
2	**1.460**	**0.000**	**250.20**
3	**0.200**	**1.230**	**10.58**
.	**.**	**.**	**.**
.	**.**	**.**	**.**
.	**.**	**.**	**.**
l	**1.460**	**0.000**	**125.00**
Exit medium Air	**1.000**	**0.000**	**-**

(c) Performance of the submitted sample measured by the participant

Participant name(s): John Doe, …
Affiliation name: X
Contact person address: 1234 Farmers Lane, Eureka CA
Contact person email: JDoe@XYZ.com
Sample description: Doe 1
Total physical thickness Σd (nm): 3500.00
Design calculated merit function *MF*: 1.0000
Sample measured merit function *MF*: 3.0000

i	Wavelength (nm)	Measured $T_{0,i}$
1	450.0	0.7507
2	451.0	0.7478
3	452.0	0.7449
4	453.0	0.7419
5	454.0	0.7386
6	455.0	0.7345
7	456.0	0.7304
8	457.0	0.7263
9	458.0	0.7217
10	459.0	0.7168
11	460.0	0.7119
12	461.0	0.7076
13	462.0	0.7041
14	463.0	0.7006
15	464.0	0.6971
16	465.0	0.6923
17	466.0	0.6864
18	467.0	0.6806
19	468.0	0.6748
20	469.0	0.6701
21	470.0	0.6659
22	471.0	0.6617
23	472.0	0.6572
24	473.0	0.6523
25	474.0	0.6473
⋮	⋮	⋮
622	1071.0	0.7852
623	1072.0	0.7887
624	1073.0	0.7922
625	1074.0	0.7957
626	1075.0	0.7972

i	Wavelength (nm)	Measured $T_{s10,i}$
1	450.0	0.7507
2	451.0	0.7478
3	452.0	0.7449
4	453.0	0.7419
5	454.0	0.7386
6	455.0	0.7345
7	456.0	0.7304
8	457.0	0.7263
9	458.0	0.7217
10	459.0	0.7168
11	460.0	0.7119
12	461.0	0.7076
13	462.0	0.7041
14	463.0	0.7006
15	464.0	0.6971
16	465.0	0.6923
17	466.0	0.6864
18	467.0	0.6806
19	468.0	0.6748
20	469.0	0.6701
21	470.0	0.6659
22	471.0	0.6617
23	472.0	0.6572
24	473.0	0.6523
25	474.0	0.6473
⋮	⋮	⋮
622	1071.0	0.7901
623	1072.0	0.7915
624	1073.0	0.7929
625	1074.0	0.7943
626	1075.0	0.7957

i	Wavelength (nm)	Measured $T_{s50,i}$
1	480.0	0.3230
2	481.0	0.3224
3	482.0	0.3212
4	483.0	0.3201
5	484.0	0.3189
6	485.0	0.3177
7	486.0	0.3166
8	487.0	0.3153
9	488.0	0.3140
10	489.0	0.3127
11	490.0	0.3113
12	491.0	0.3100
13	492.0	0.3086
14	493.0	0.3070
15	494.0	0.3054
16	495.0	0.3039
17	496.0	0.3023
18	497.0	0.3008
19	498.0	0.2994
20	499.0	0.2981
21	500.0	0.2968
22	501.0	0.2955
23	502.0	0.2942
24	503.0	0.2930
25	504.0	0.2918
⋮		⋮
582	1061.0	0.3366
583	1062.0	0.3371
584	1063.0	0.3375
585	1064.0	0.3379
586	1065.0	0.3384

OIC 2019 Measurement Problem

Organizer Team:

Angela Duparré, *Fraunhofer Institut Angewandte Optik & Feinmechanik; Jena, Germany*
Detlev Ristau, *Laser Zentrum Hannover, Germany*

Evaluation Team:

Sven Schröder and Marcus Trost, *Fraunhofer Institut Angewandte Optik & Feinmechanik; Jena, Germany*

General Remarks

OIC Measurement Problems, for the first time organized in 2004, have since gained continuously growing interest. Their results significantly contributed to the information about potentials and limits of well-established measurement techniques to investigate optical thin film coatings. While the preceding Measurement Problems comprised a variety of tasks concerning transmittance and reflectance properties, the 2019 Measurement Problem focusses on light scattering loss measurements.

Description of the Problem

The sample is a fused silica substrate coated on one side with a multilayer dielectric thin film system.

Task: Determine the

- total backscattering $S_b(\lambda)$ (scattering loss into the hemisphere of reflectance) and total forward scattering $S_f(\lambda)$ (scattering loss into the hemisphere of transmittance) – if possible both, but at least one of them –
- as well as the reflectance $R(\lambda)$ and transmittance $T(\lambda)$
- in the spectral region from 300nm through 750nm, for near normal incidence and unpolarised light.

Note: The above-named quantities refer to the sample as a whole.

Measurement Technique: Spectrophotometer with integrating sphere, or any other techniques

Further optional tasks:

Participants are encouraged to extend their measurements and activities according to their capabilities and submit additional information about the coating, such as

- extended spectral region
- specific additional light scattering measurements at particular wavelengths
- reverse engineering approaches to uncover the coating design

Note:

Unlike the instructions for the preceding Measurement Problems, this time the samples shall remain with the participants and not be sent back to the organizers.

Sample Specification and Distribution

Sample size: 25 mm diameter, thickness: between 4 mm and 6 mm

The samples will be sponsored by a German company which is active in the field of thin film optics production and will be distributed by the Fraunhofer Institute Jena upon request of the Measurement Problem participant.

Requests for samples are to be sent by e-mail to
angela.duparre@iof.fraunhofer.de   subject: "OIC 2019 Measurement Problem"

Deadline of request for samples: 7 November 2018

The samples will be delivered to the MP participants in January 2019.

Submission of Results

Participants should send their results by e-mail to
marcus.trost@iof.fraunhofer.de   subject: "OIC 2019 Measurement Problem results"

Deadline for submission of results: 15 March 2019

Format of results:

E-mail containing the participant's name, affiliation, e-mail address, mailing address, phone and fax numbers (listed in this order) and

separate attached files (each again including the participant's name and affiliation):

1) Tables listing the measured values (preferred format: excel; otherwise ASCII): columns: wavelength / nm, $S_b(\lambda)$, $S_f(\lambda)$, $T(\lambda)$, $R(\lambda)$

2) Word document containing:
- Description of the measurement and data evaluation procedures
- Specification of uncertainty of measurement
- Participants are encouraged to be generous in also delivering information on the types of equipment they have used.
- Any additional comments

3) Word document containing the description of additional investigations

Evaluation Procedure of the Submitted Results

The results of the Measurement Problem will be evaluated according to the regulations established in round robin experiments:

The submitted data will be evaluated according to the relative deviations of the results of the different labs from each other. The MP results will be presented at the OIC 2019 meeting in an anonymous manner. The list of participants is presented, but the sample number (laboratory number) related to the results does not uncover the respective participant. Each participant recognizes only him-/herself by the given number.