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Practical Designs for the Next Generation of Eyeglass Coatings

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The advent of Zoom and Team Meetings and other face-time communications has made the annoyance of reflections from uncoated eyeglasses more apparent. Even the residual reflections from some of the current commercially available antireflection (AR) coatings can be distracting. The goal of this work is to find the most practical recommended AR coating design for the next generation of eyeglass coatings which will effectively eliminate these annoying reflections which are currently seen when in a Zoom or Teams meeting with those who do not have sufficiently well-coated glasses. The evolution of the designs from many layers to the recommended four layers will be presented.

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Practical Designs for the Next Generation of Eyeglass Coatings

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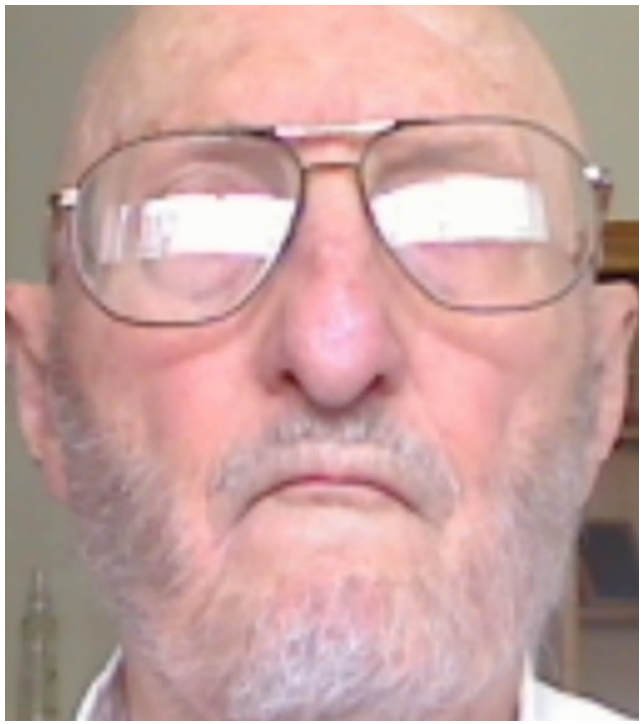
Abstract

The advent of Zoom and Team Meetings and other face-time communications has made the annoyance of reflections from uncoated eyeglasses more apparent. Even the residual reflections from some of the current commercially available antireflection (AR) coatings can be distracting. The goal of this work is to find the most practical recommended AR coating design for the next generation of eyeglass coatings which will effectively eliminate these annoying reflections which are currently seen when in a Zoom or Teams meeting with those who do not have sufficiently well-coated glasses.

The evolution of the designs from many layers to the recommended four layers will be presented.

Screen Captures Online

Eyeglass Coatings



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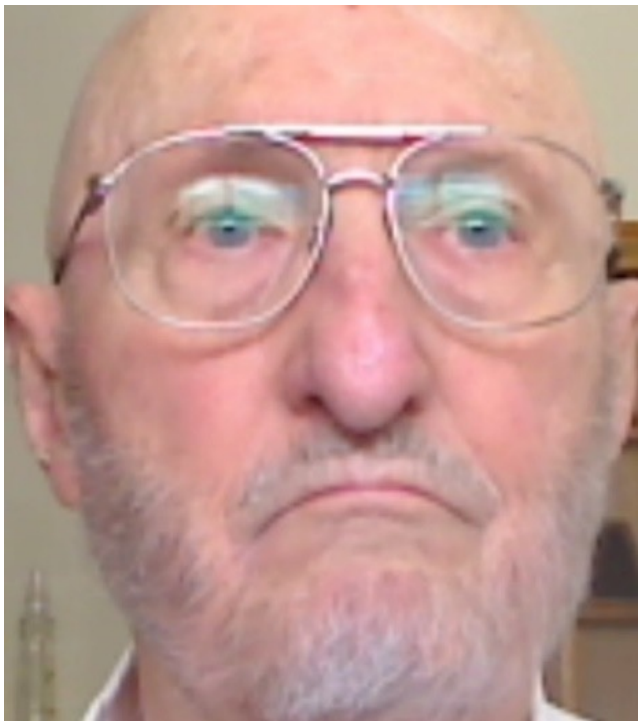
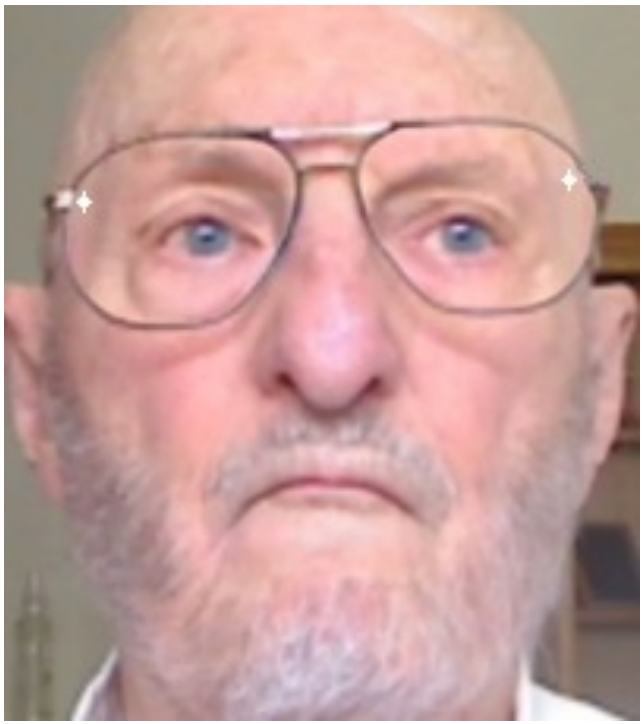
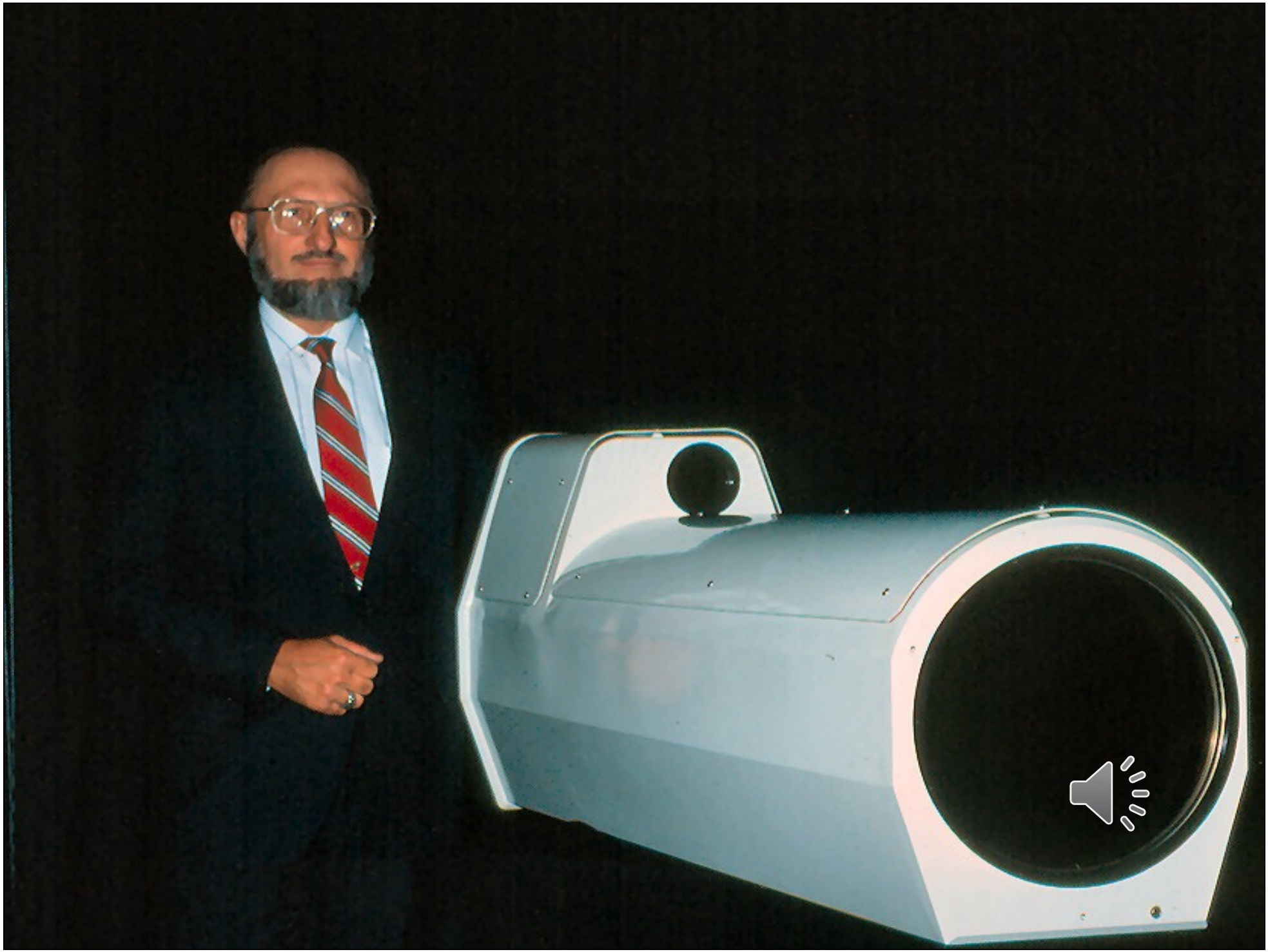


Current



New Goal



FilmStar Workbook Macros

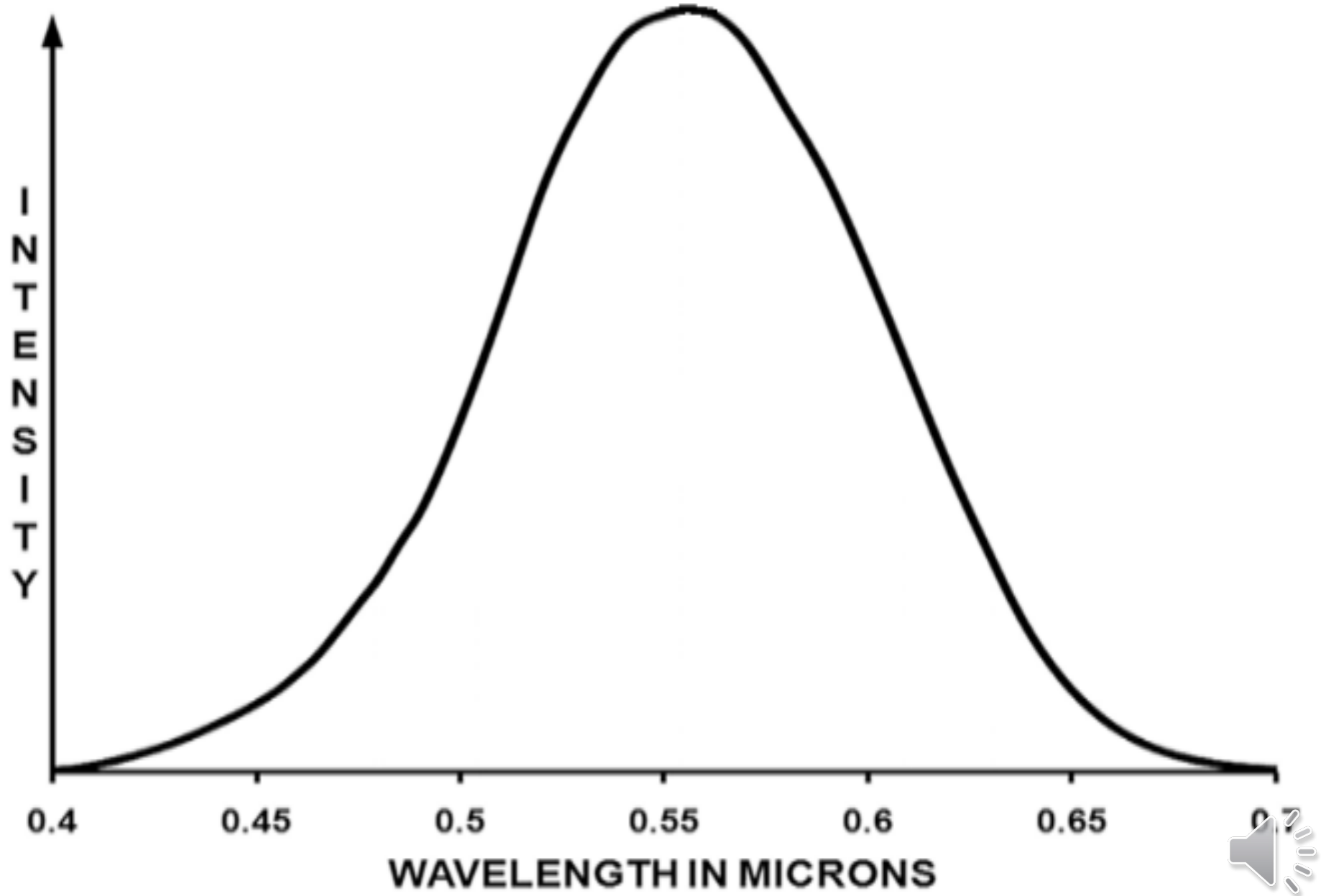
B7 =SQRT((B3-B4)^2+(C3-C4)^2+(D3-D4)^2+(B4-B5)^2+(C4-C5)^2+(D4-D5)^2)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1														
2		x	y	Y										
3	CIE Plus %	0.206	0.236	0.142										
4	CIE Min. %	0.278	0.280	0.097										
5	Targets	0.267	0.333	0										
6														
7	Objective	0.14653												
8														
9														
10	Macro	BasExec S$	=Design$\|DesignAdjust 2,"",WbGetNum("G13")\|Calculate\|GetCieData ya!, yb!, yL!\|WbSetNum "F3", ya\|WbSetNum "G3", yb\|WbSetNum "H3", yL											
11		BasExec S$	=Design$\|DesignAdjust 2,"",WbGetNum("H13")\|Calculate\|GetCieData ya!, yb!, yL!\|WbSetNum "F4", ya\|WbSetNum "G4", yb\|WbSetNum "H4", yL											
12			Plus	Minus										
13	% to Vary =	5	1.05	0.95										
14														

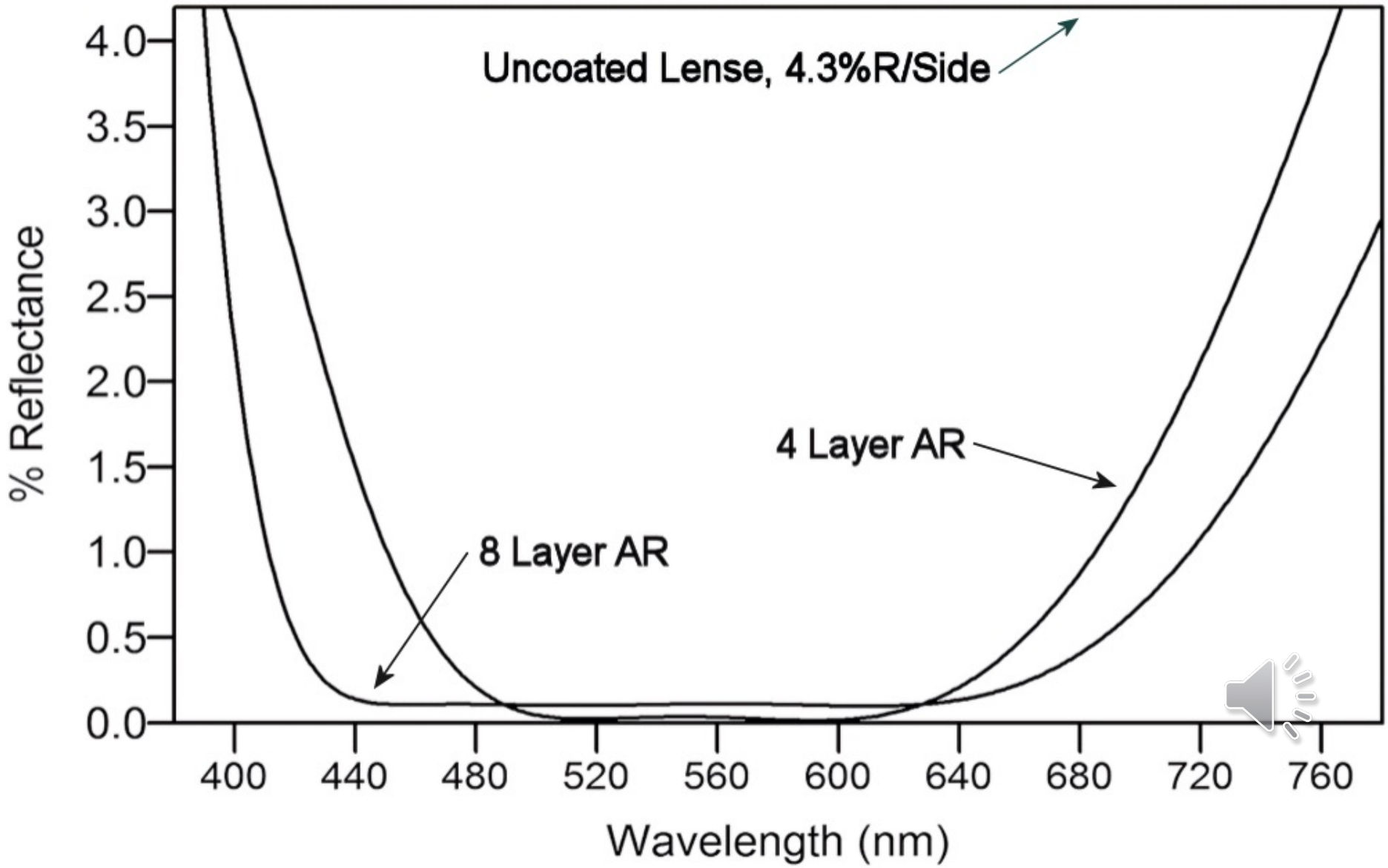
Uncoated & Current Coating

Note: Color Boosted 100X For Display

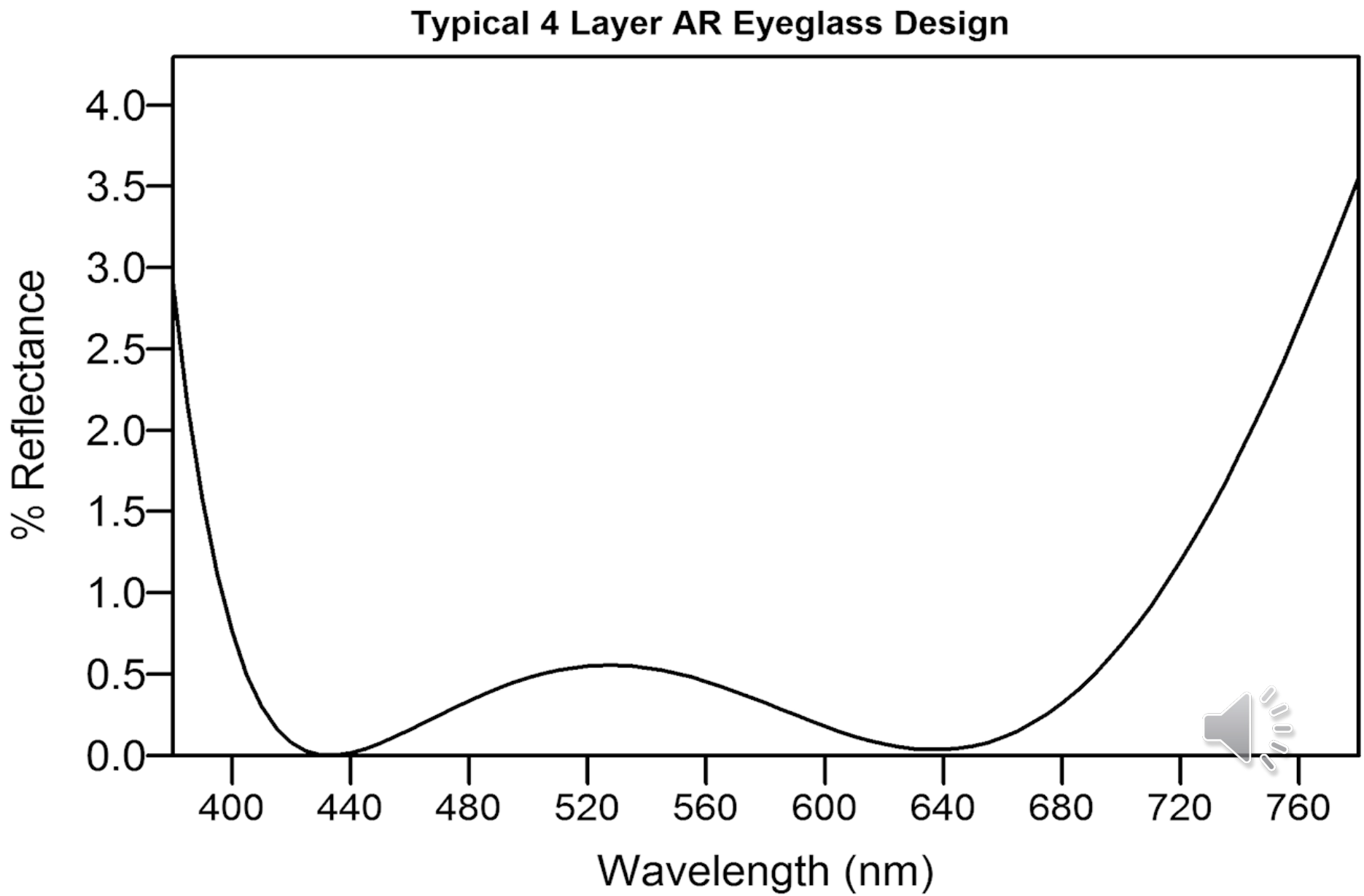
Photopic Response of Eye



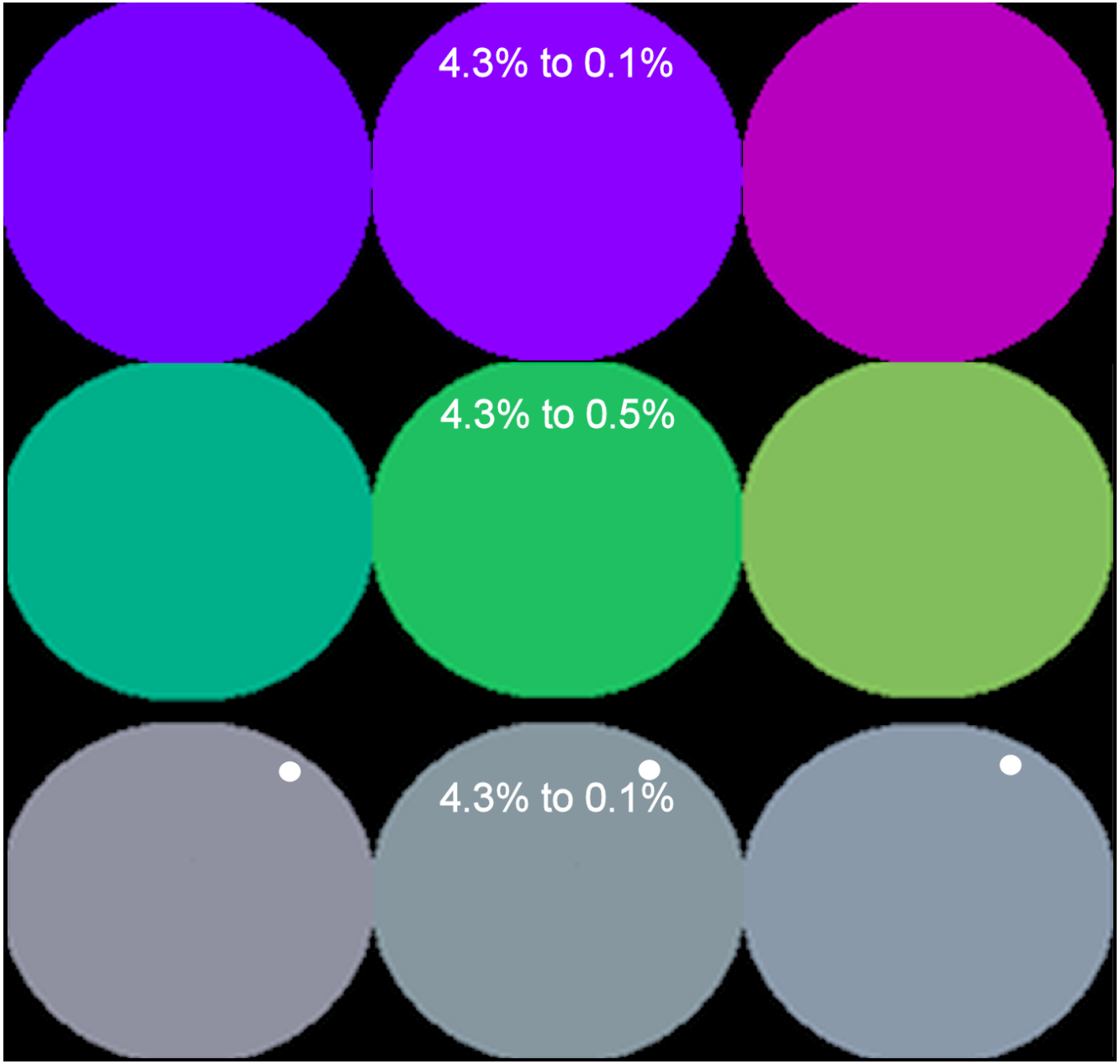
4 & 8 Layer Photopic ARs



TYPICAL EYEGLASS AR



Color Changes of Coatings



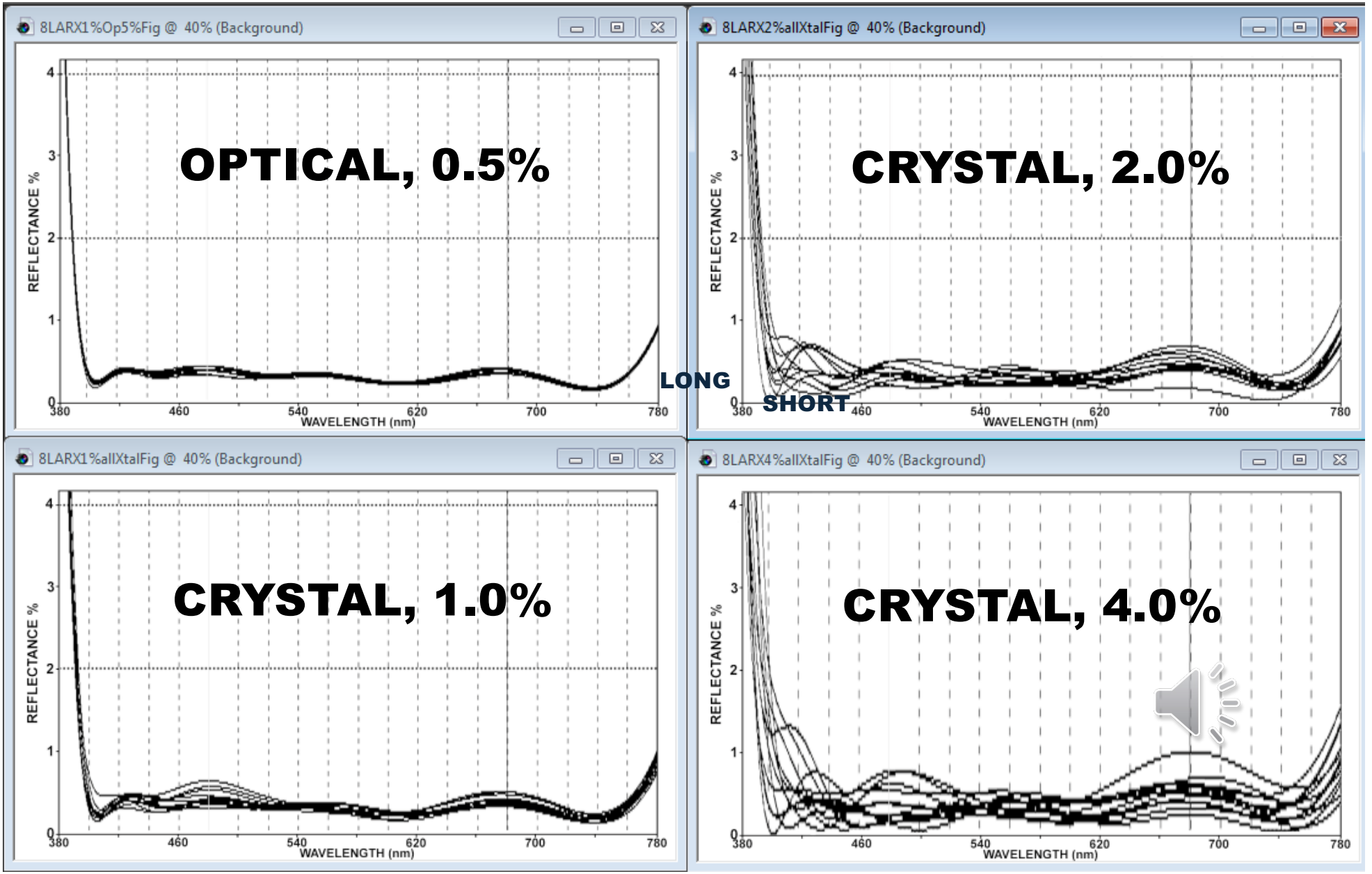
Realizing the Goal

How might we progress from the current "state of the art" coating to the New Era Goal Coating?

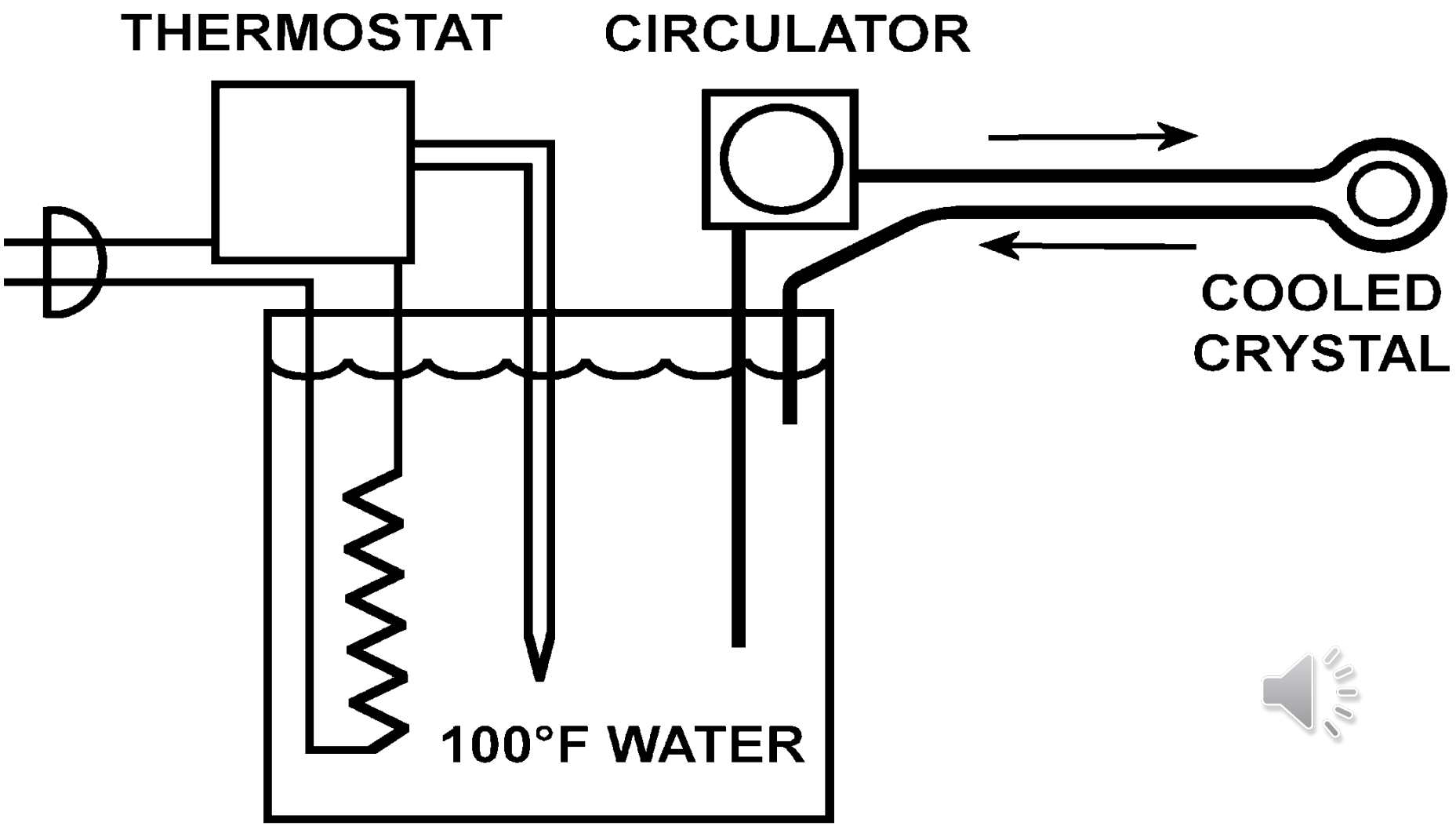
The common production issues limiting performance now are inadequate reproducibility of factors such as layer termination, pressure, rate, temperature, uniformity, etc.

Each of a few of the most likely culprits in lack of reproducibility will be examined, one at a time, starting with layer termination.

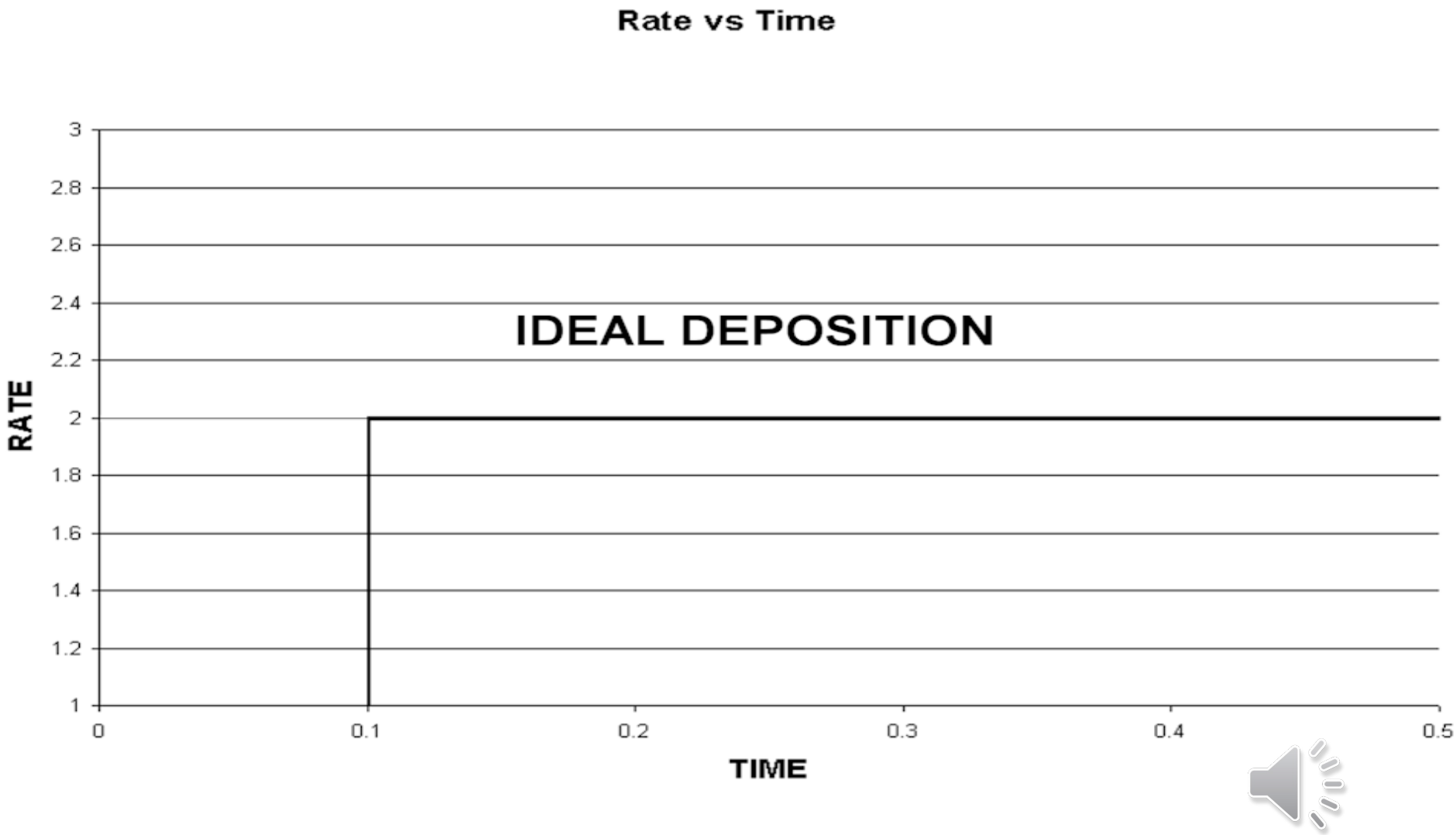
8LAR, VARIOUS MONITORS



CONTROLLED TEMPERATURE



RATE CONTROL

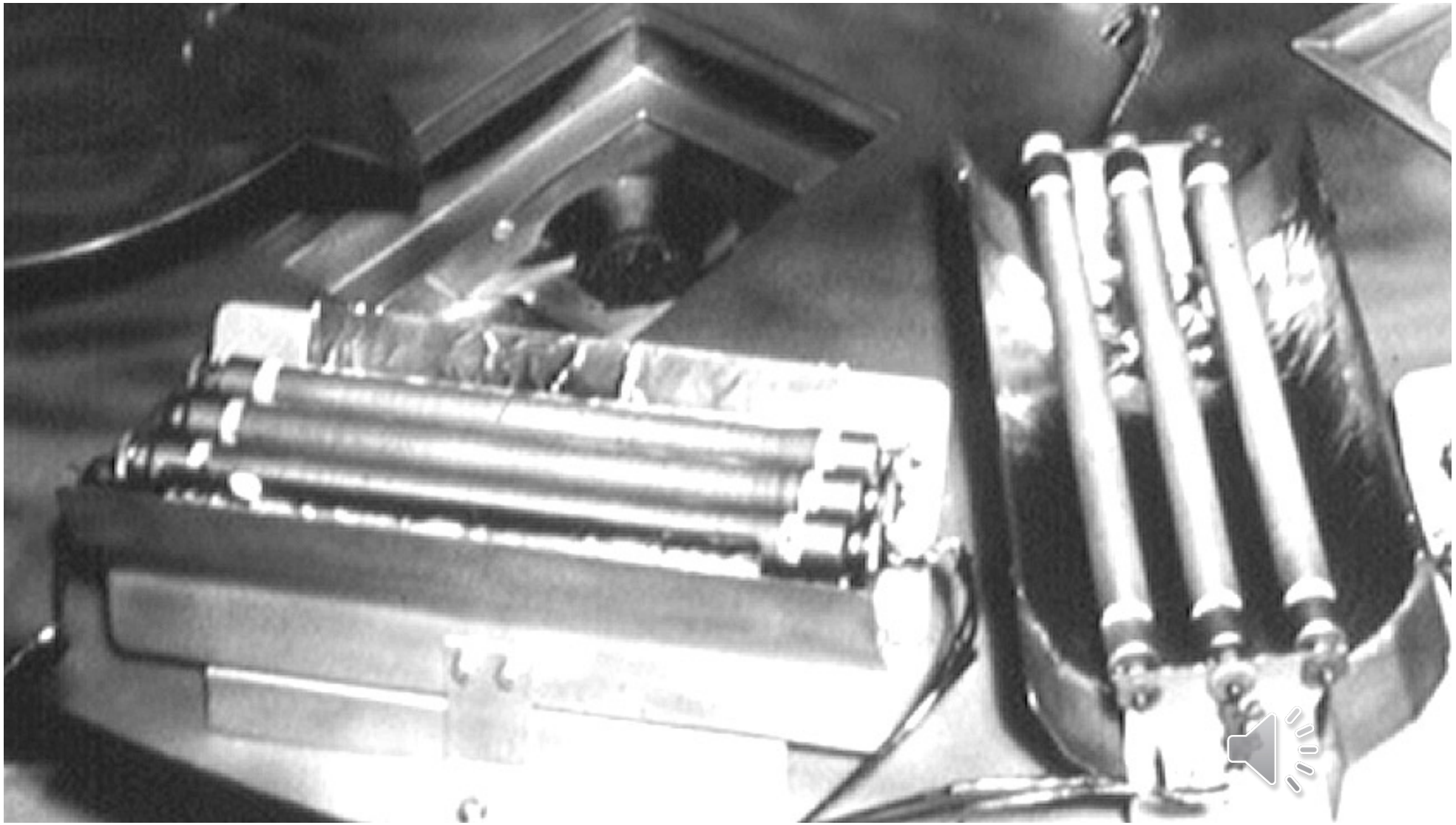


Ideal rate when shutter opens to exact desired rate and is constant throughout the deposition.

POOR RATE CONTROL

Actual rate when shutter opens is NOT to desired rate and is constant throughout the deposition.

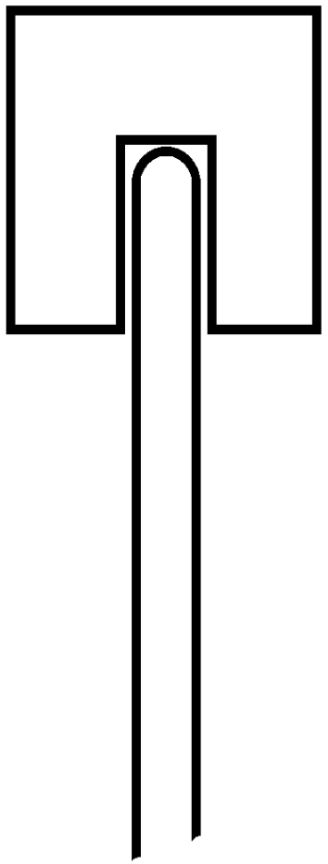
BOTTOM HEATERS



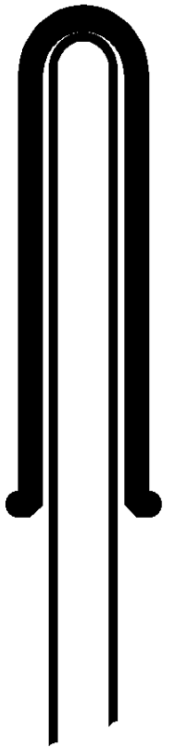
TEMPERATURE SENSING

THERMOCOUPLE

GLASS BLOCK



SMALL TEST TUBE



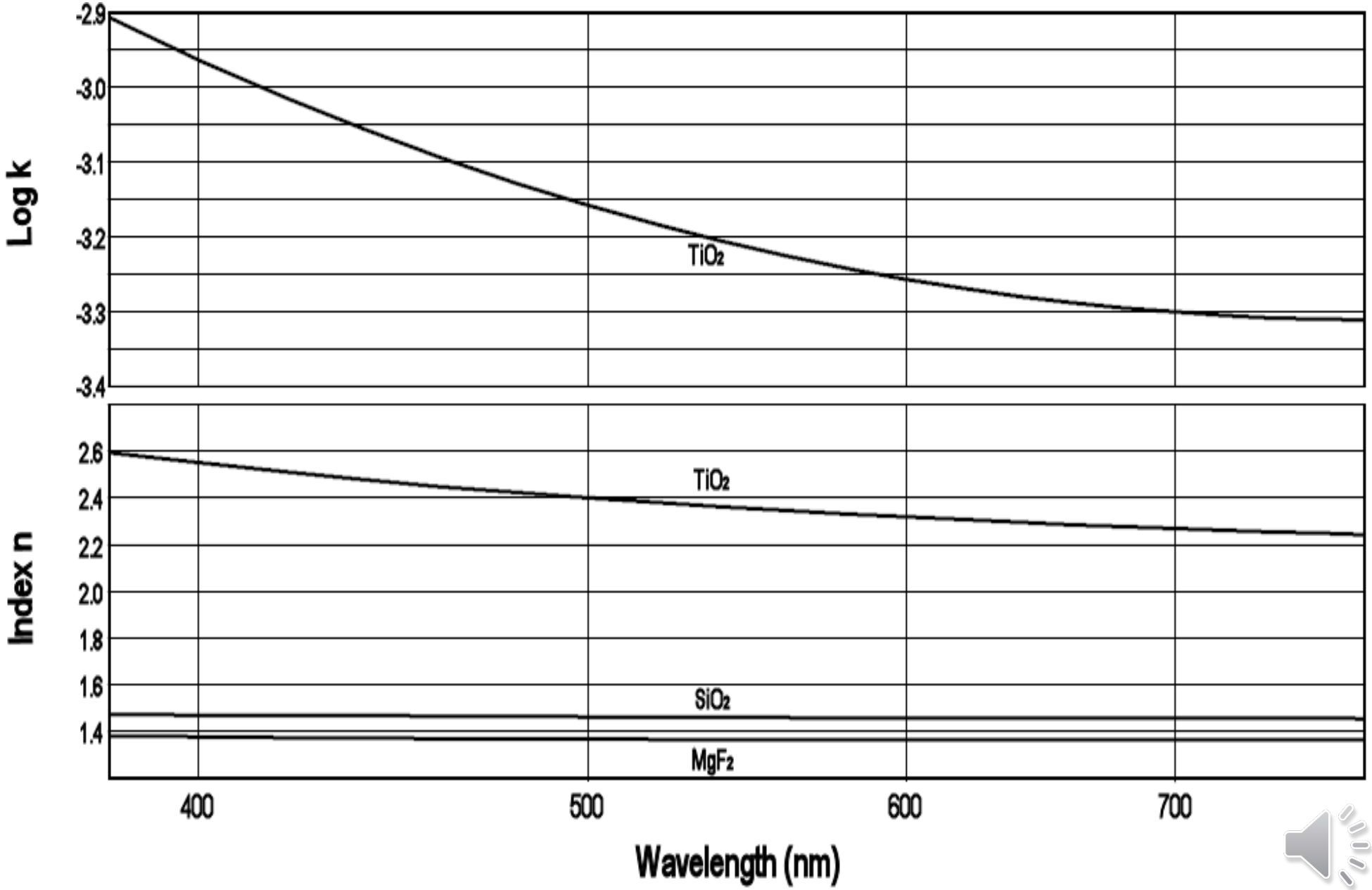
Pressure during the process is important because it will affect the index and possibly other properties of the coating like stoichiometry. Keep in mind that after the pump-down, the residual gas in the chamber is water vapor which is competing for a place on the substrate. If there is no reactive gas like oxygen in the process and no leaks in the chamber, then the best that can be done is to always deposit at the same pressure. The degree of “dirty” of the chamber is also important. Some people clean 1/3 of the chamber after every run, thus having constant level of clean or dirty.

OTHER FACTORS

Uniformity and other things should be reasonably stable if all of the other things mentioned above are stable.

The basic limitation is the reproducibility of the deposition processes. It is hoped that the above suggestions will help in reducing process variations.

Indices Used in Designs



18-Layer Design Details

FilmStar DESIGN 08-08-2024 15:25

Design Wave 555 nm FWD ignore Side 2 Angle 0

Design (from substrate) - FILM Archive 725CIE_3C_Opt555only

1 .21721H 2 .34524L 3 1.96582H 4 .38134L 5 .16473H
6 1.11409L 7 .23071H 8 .35245L 9 .70657H 10 .27301L
11 .38205H 12 1.23643L 13 .09595H 14 .4366L 15 1.10175H
16 .04043L 17 .60043H 18 .90583F

Film Indices Symbols: L,H,F:QWOT=1

Indx Symb	File $Funct	A(n)	B(k)	C	D	E	F	G
AIR		1.0	0	·	·	·	·	·
SUB		1.52	0	·	·	·	·	·
L		1.46	0	·	·	·	·	·
H		2.35	0	·	·	·	·	·
F		1.38	0	·	·	·	·	·

18-Layer Design Details

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SUB		1.52	0	·	·	·	·	·
L		1.46	0	·	·	·	·	·
H		2.35	0	·	·	·	·	·
F		1.38	0	·	·	·	·	·

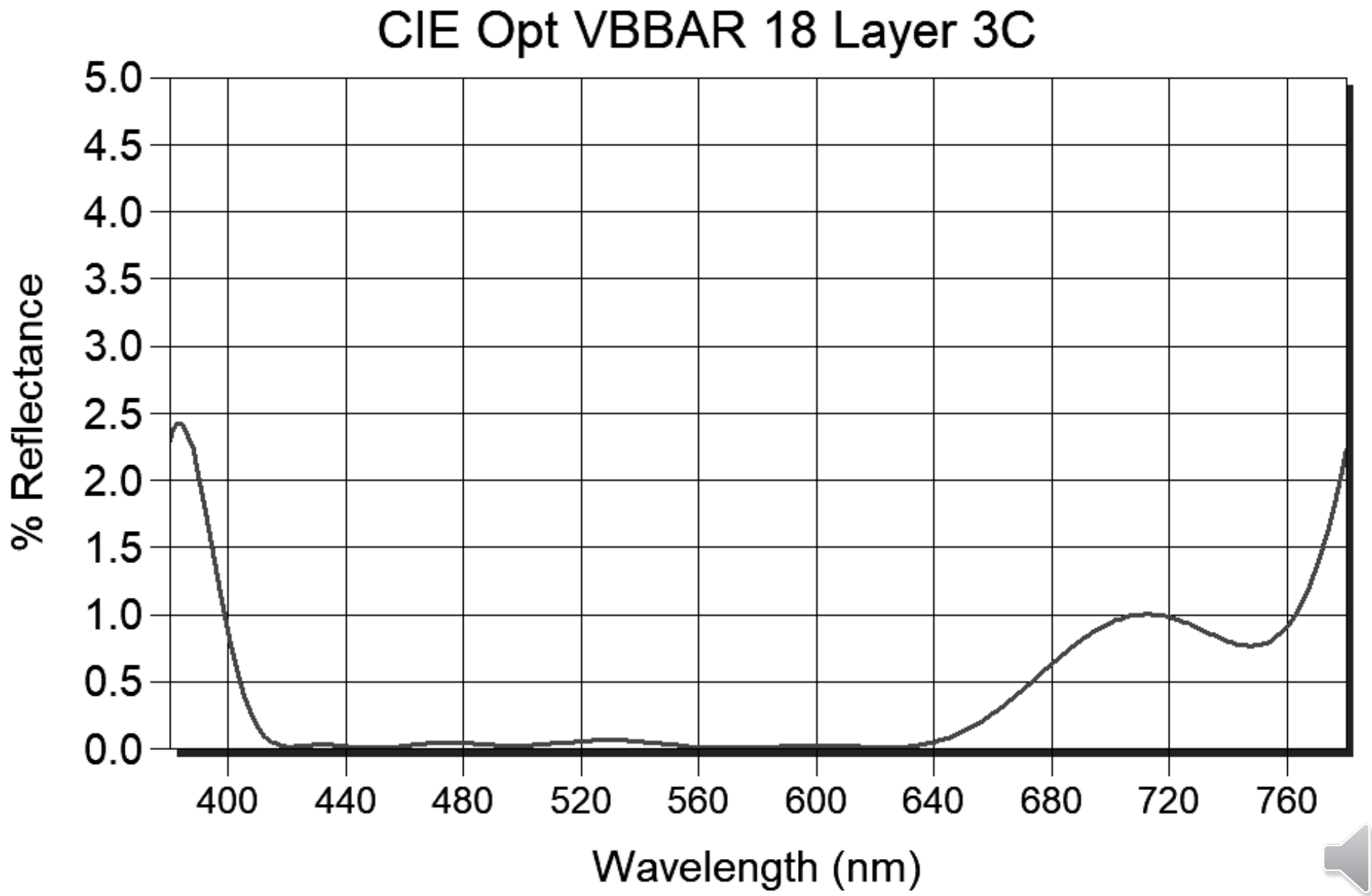
18-Layer Colors CIE1931

With ±5% Overall Thickness Errors

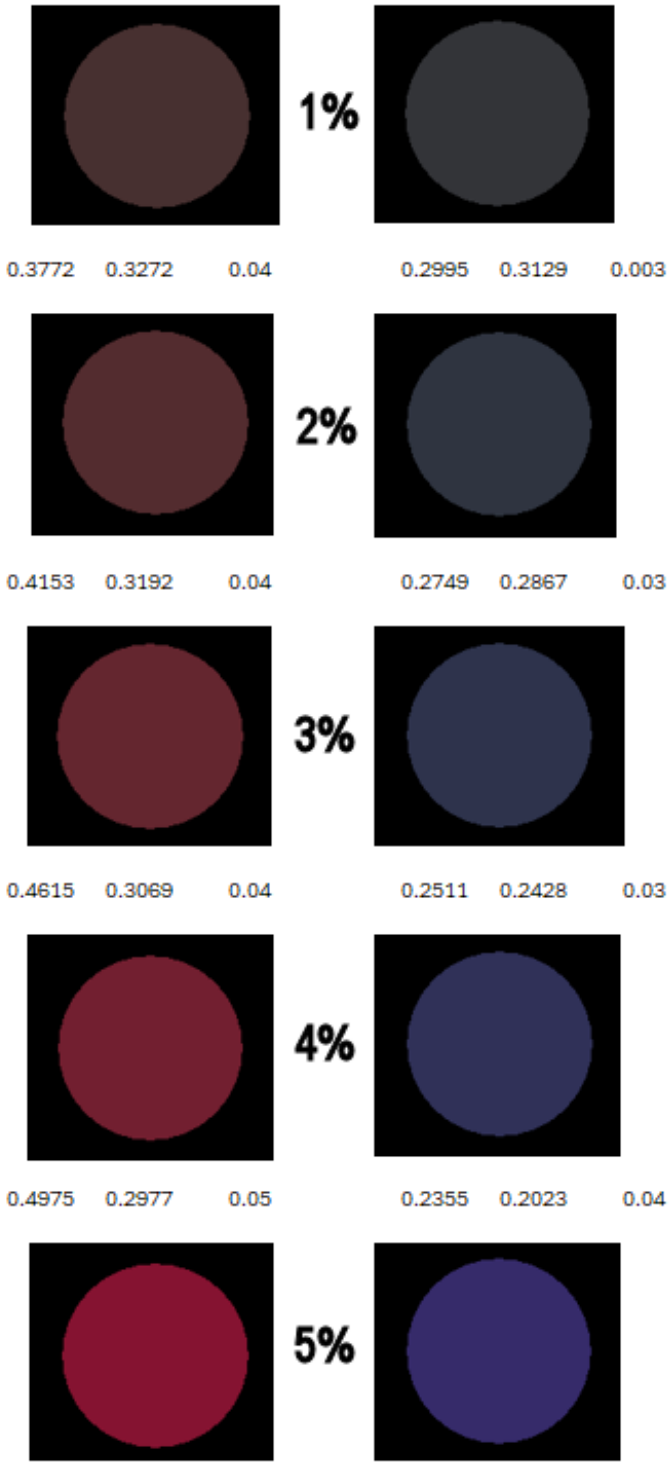
.5351,.2905,.06 .3352,.3279,.04 .2209,.1557,.04

x, y, z

18-Layer Spectrum



18-Layer



% Overall Thickness Errors

12-Layer Design Details

FilmStar DESIGN 08-03-2024 14:01

Design Wave 555 nm FWD ignore Side 2 Angle 0

Design (from substrate) - FILM Archive 803CIE_2C_DispOpt

1 .02463H 2 .70484L 3 .05457H 4 .92132L 5 .01267H
6 1.36025L 7 .21242H 8 .34013L 9 1.60072H 10 .10943
11 .21527H 12 .83534F

Film Indices Symbols: L,H,F:QWOT=1

Indx Symb	File $Funct	A(n)	B(k)	C	D	E	F	G
AIR		1.0	0	·	·	·	·	·
SUB	BK7_Schott	·	·	·	·	·	·	·
L	SiO2_Palik	·	·	·	·	·	·	·
H	TiO2$CauchyK	·	·	·	·	·	·	·
F		1.38	0	·	·	·	·	·

12-Layer Colors CIE1931

With ±5% Overall Thickness Errors

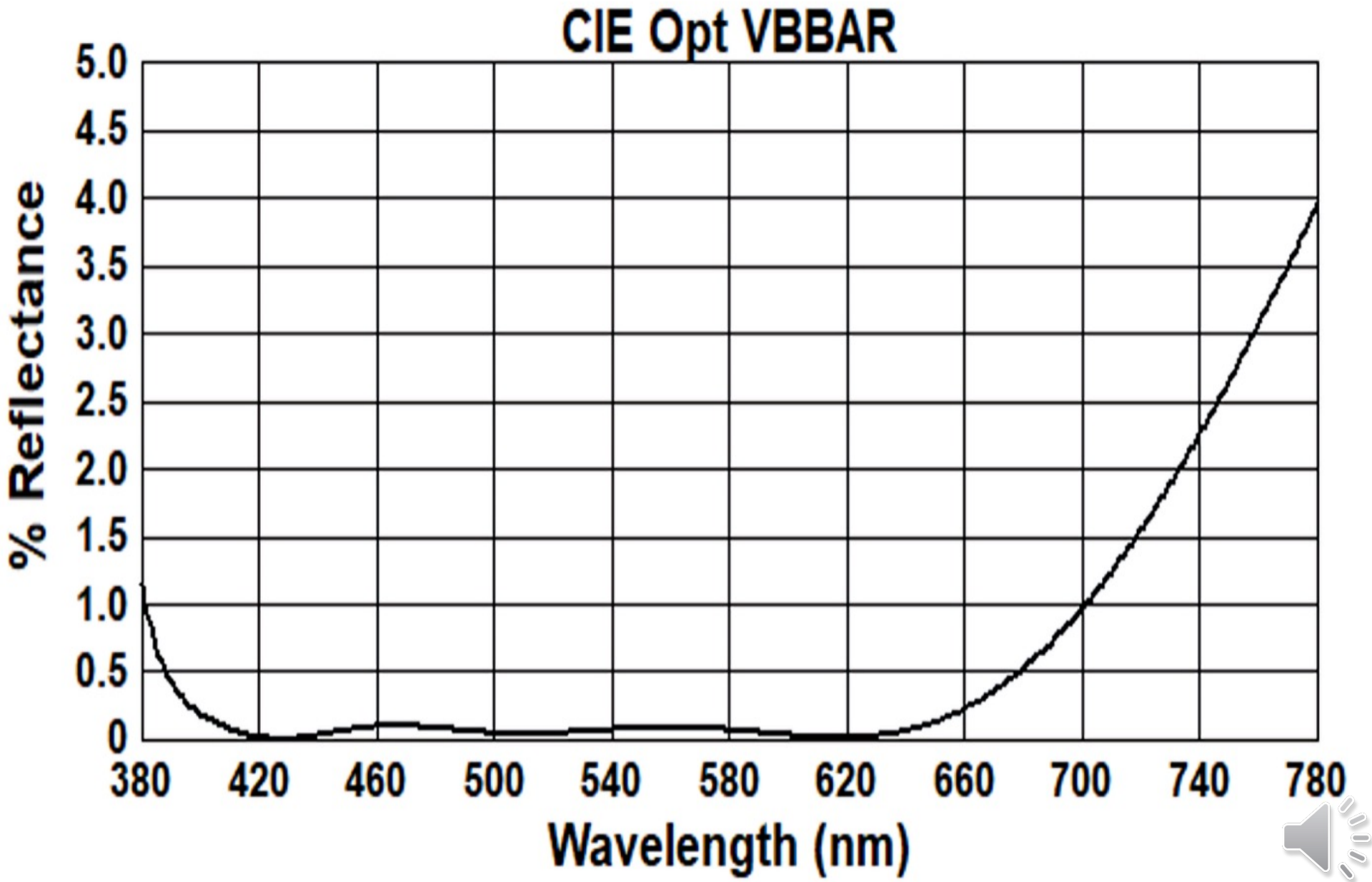
0.4738 0.302 0.08

0.3133 0.334 0.07

0.3148 0.3397 0.08

x, y, z

12-Layer Spectrum



6-Layer Design Details

FilmStar DESIGN 08-03-2024 14:15

Design Wave 555 nm FWD ignore Side 2 Angle 0

Design (from substrate) - FILM Archive 803CIE_1C_DispOpt

1 .2108H 2 .32088L 3 1.6009H 4 .10922L 5 .21614H
6 .84035F

Film Indices Symbols: L,H,F:QWOT=1

Indx Symb	File $Funct	A(n)	B(k)	C	D	E	F	G
AIR		1.0	0	·	·	·	·	·
SUB	BK7_Schott	·	·	·	·	·	·	·
L	SiO2_Palik	·	·	·	·	·	·	·
H	TiO2$CauchyK	·	·	·	·	·	·	·
F		1.38	0	·	·	·	·	·

6-Layer Colors CIE1931

With ±5% Overall Thickness Errors

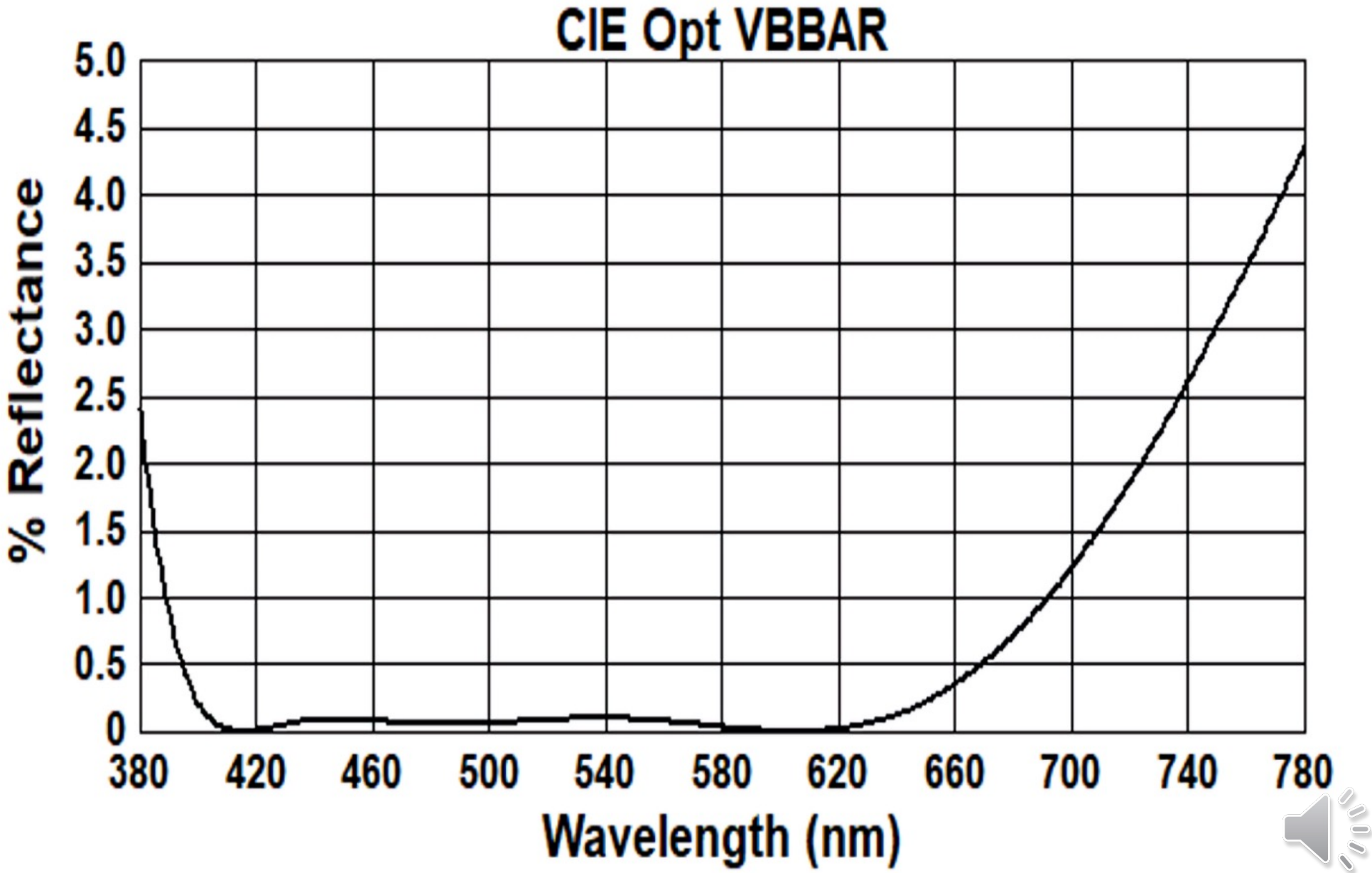
0.5252 0.2977 0.1

0.2294 0.3277 0.07

0.2728 0.3227 0.08

x, y, z

6-Layer Spectrum



4-Layer Design Details

FilmStar DESIGN 08-08-2024 18:10

Design Wave 555 nm FWD ignore Side 2 Angle 0

Design (from substrate) - FILM Archive 808CIE_1C_4L1%

1 .18615A 2 .36844B 3 1.83369C 4 .91075D

Film Indices Symbols: B,A,D,C,F,E:QWOT=1

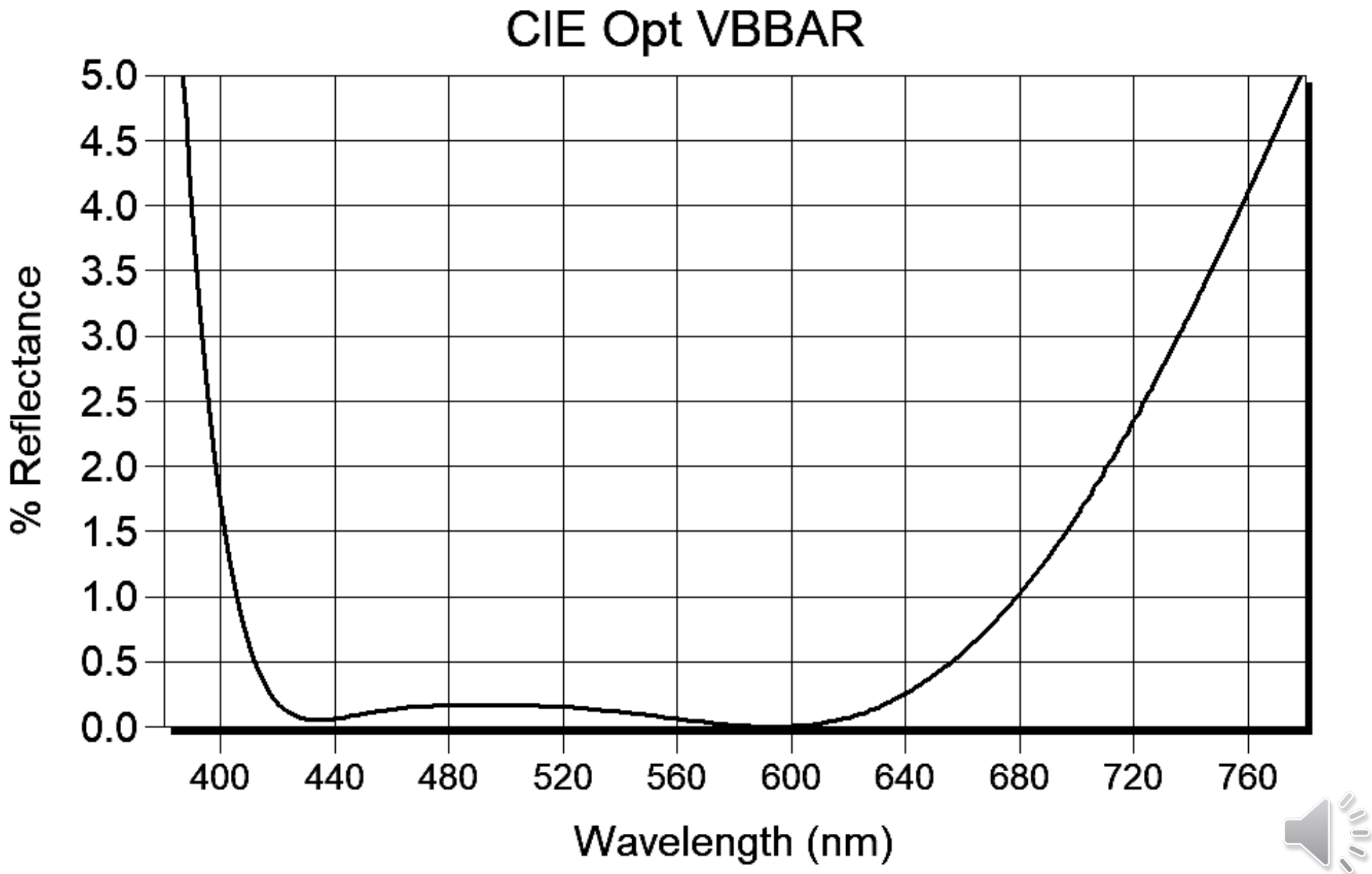
Indx Symb	File $Funct	A(n)	B(k)	C	D	E	F	G
AIR		1.0	0	·	·	·	·	·
SUB	BK7_Schott	·	·	·	·	·	·	·
B	SiO2_Palik	·	·	·	·	·	·	·
A	TiO2$CauchyK	·	·	·	·	·	·	·
D	SiO2_Palik	·	·	·	·	·	·	·
C	TiO2$CauchyK	·	·	·	·	·	·	·
F	SiO2_Palik	·	·	·	·	·	·	·
E	TiO2$CauchyK	·	·	·	·	·	·	·

4-Layer Colors CIE1931

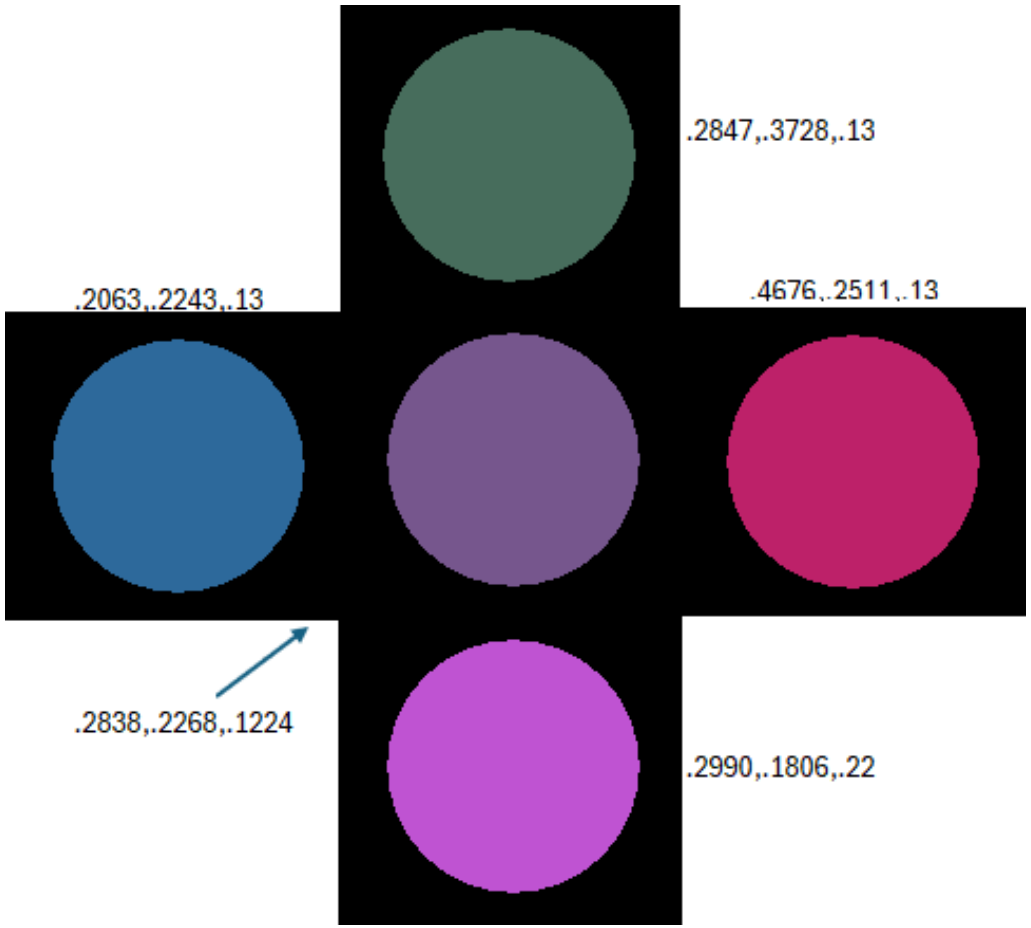
With ±5% Overall Thickness Errors

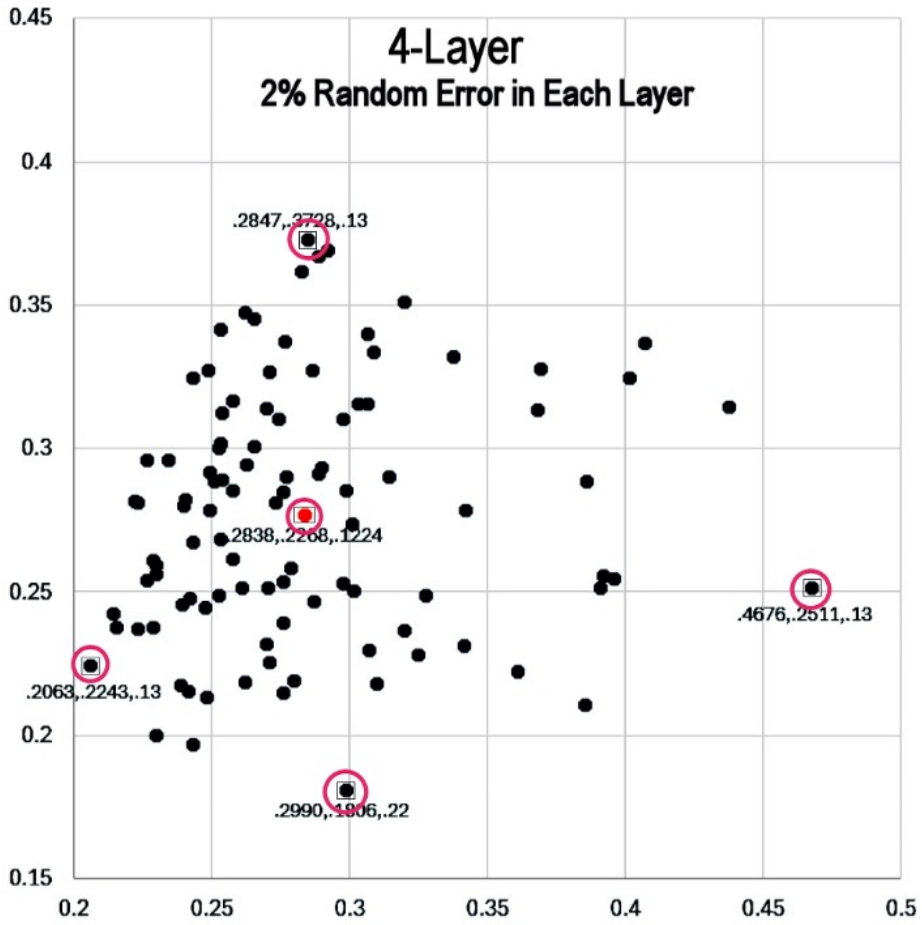
.4755, .2539,.15 .2677, .2656,.11 .2077, .2302,.15

4-Layer Spectrum

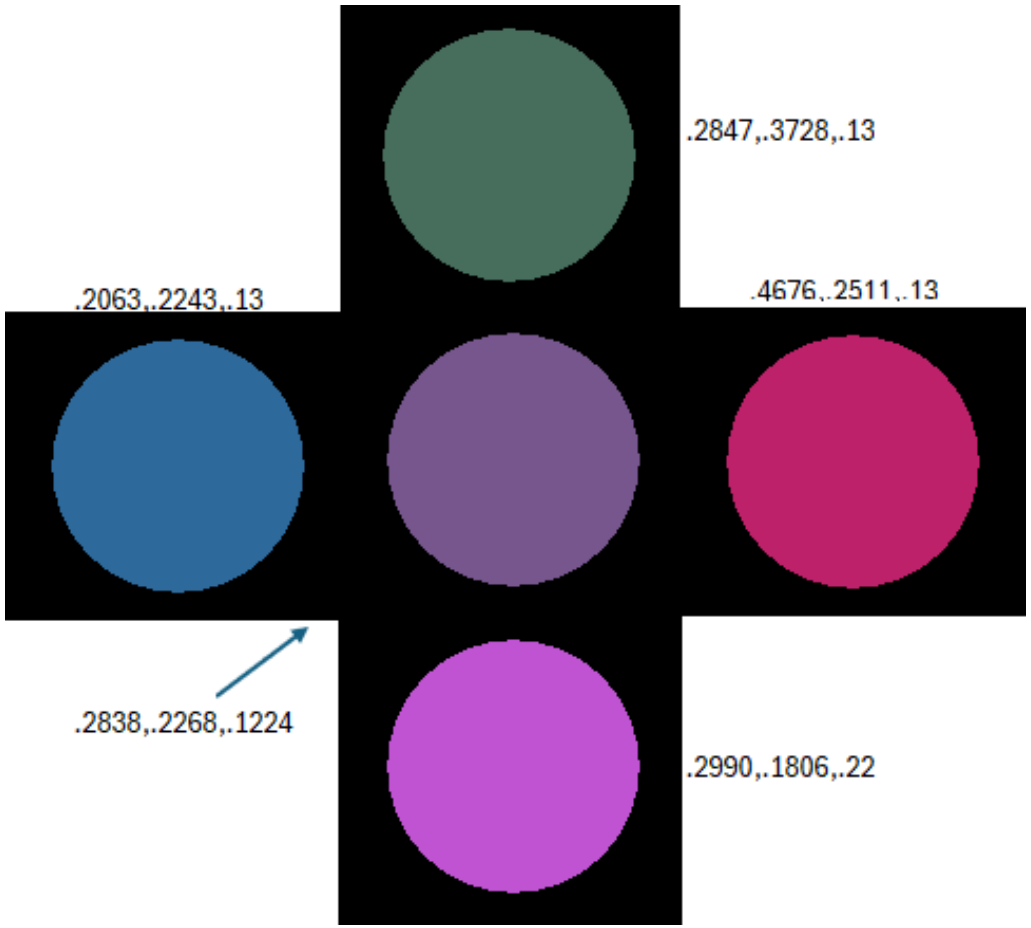


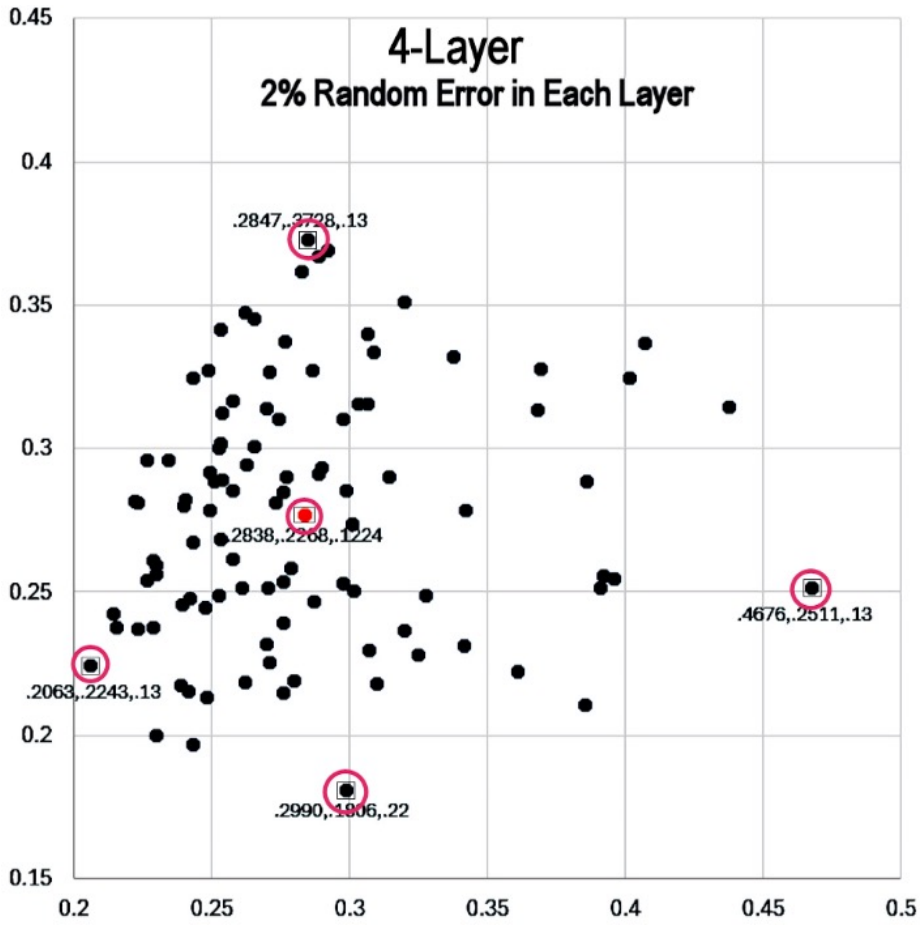
Worst Case 2% Random



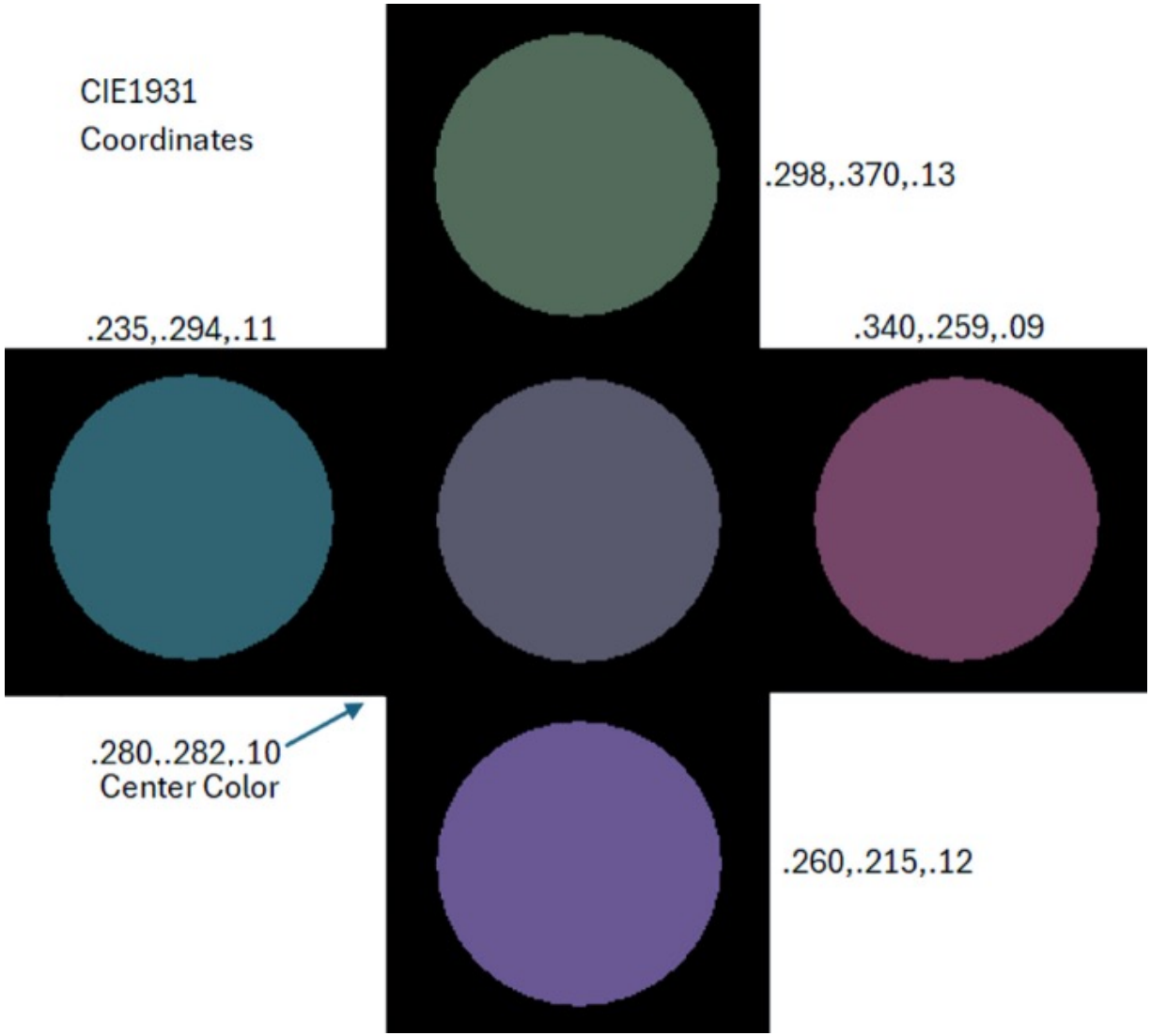


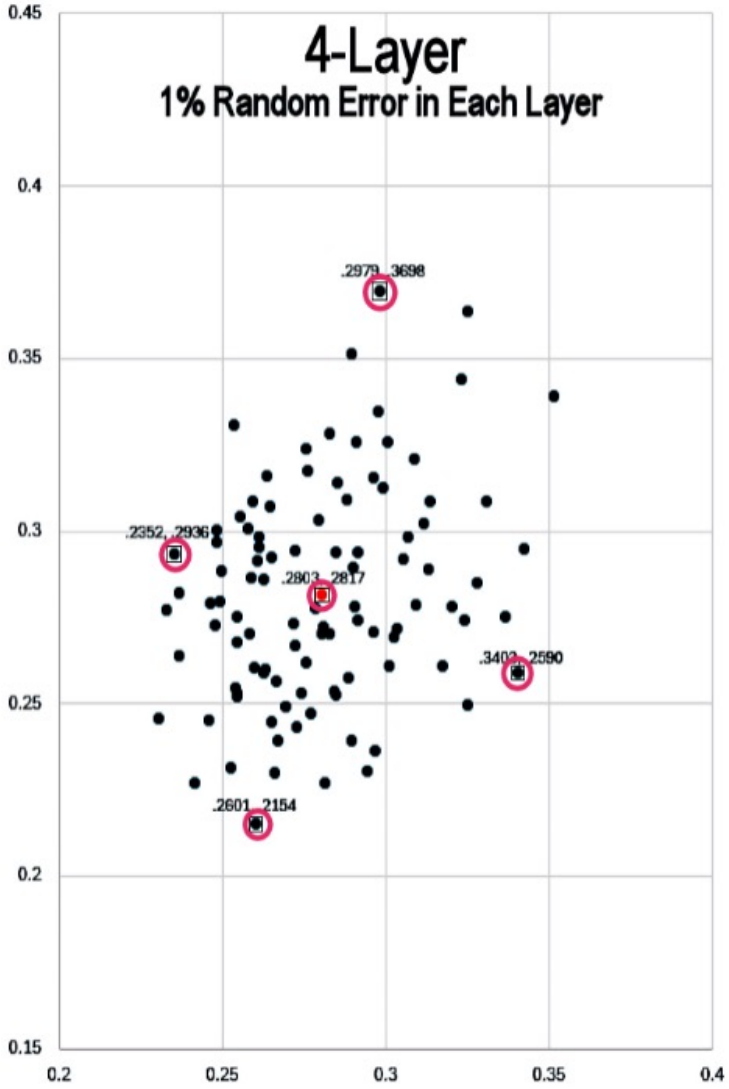
Worst Case 2% Random





Worst Case 1% Random





Conclusions

This is the recommended design for the next generation of eyeglasses.

Control the layer thicknesses and look good in Zoom and Team Meetings, etc.!