

# Thin Film Filters

OPTI 696

Mark Nimmer

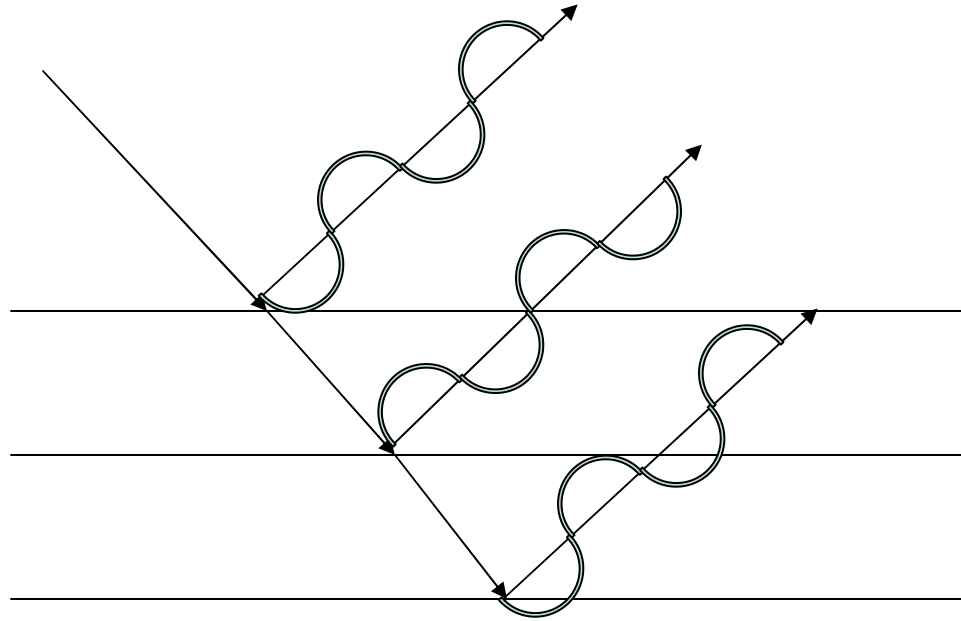
# Contents

- What is a Thin Film Filter
- Types of Filters
- Admittance Diagram
- My Designs
- Fabrication

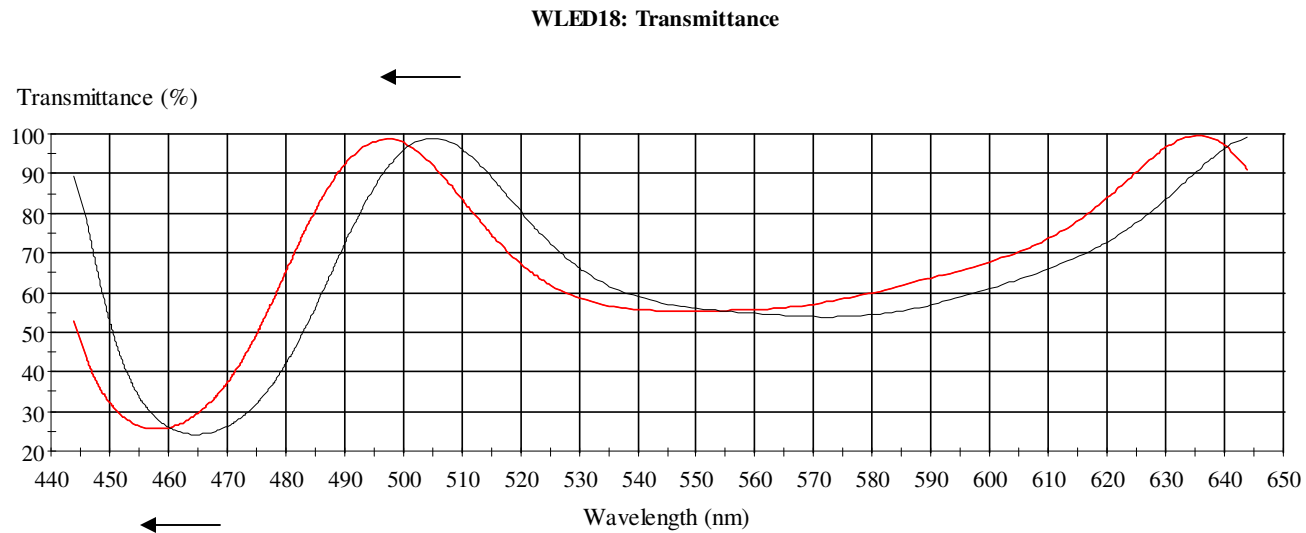
# Thin Film Filters

- Interference Filters
- Dielectrics and Metals
- AR Coating MgF<sub>2</sub>
- V-Coat
- Quarter Wave Stack
- Narrowband

# Interference Filters



# Shift with Angle



Design at Normal Incidence

Design at 20 degrees Incidence

# Dielectrics and Metals

$$Y = n + ik$$

Dielectrics

MgF<sub>2</sub>

SiO<sub>2</sub>

Al<sub>2</sub>O<sub>3</sub>

Ta<sub>2</sub>O<sub>5</sub>

TiO<sub>2</sub>

Metals

Chromium

Aluminum

Gold

Silver

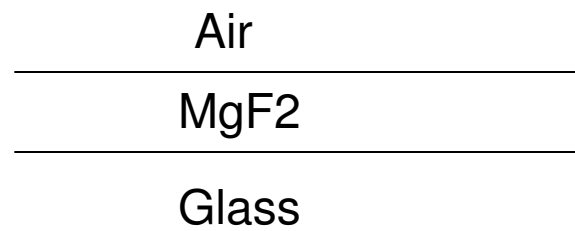
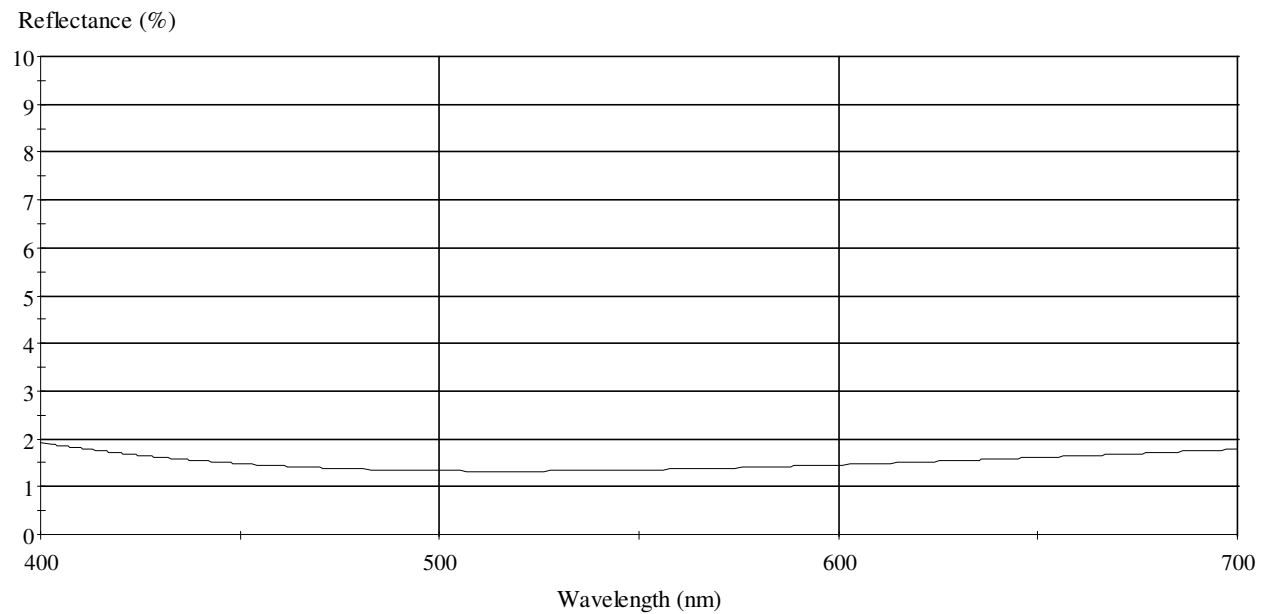
Platinum

Copper

$$e^{iY} = e^{i(n + ik)} = e^{in - k}$$

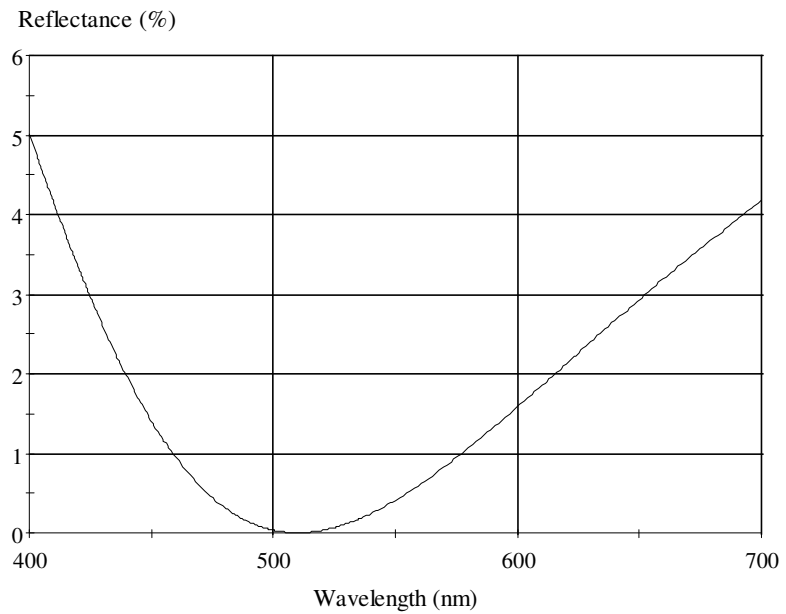
# Single Layer AR

One Layer AR: Reflectance



# V-Coat

vcoat: Reflectance



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1.49	$\lambda/4$
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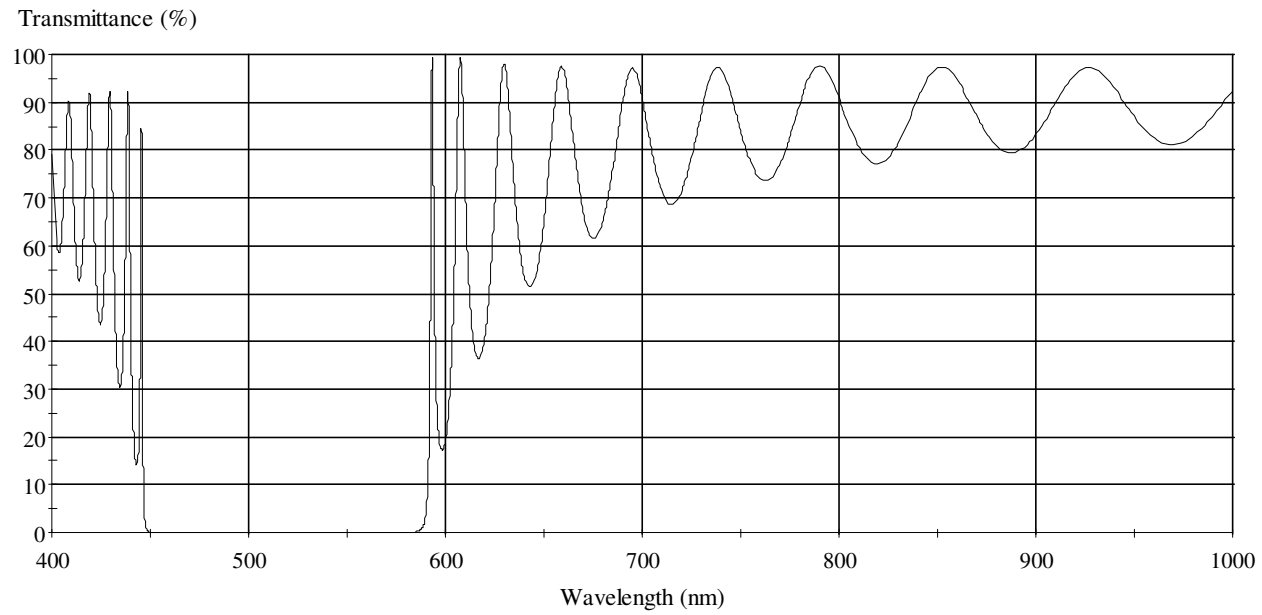
1.79	$\lambda/4$
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1.52	Sub
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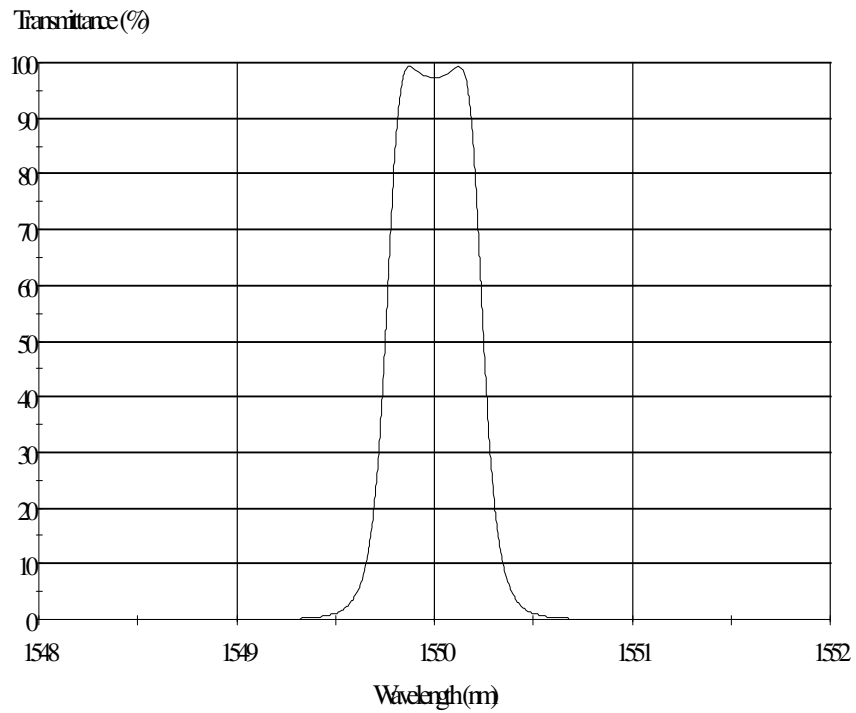
# Quarter Wave Stack

Design3: Transmittance

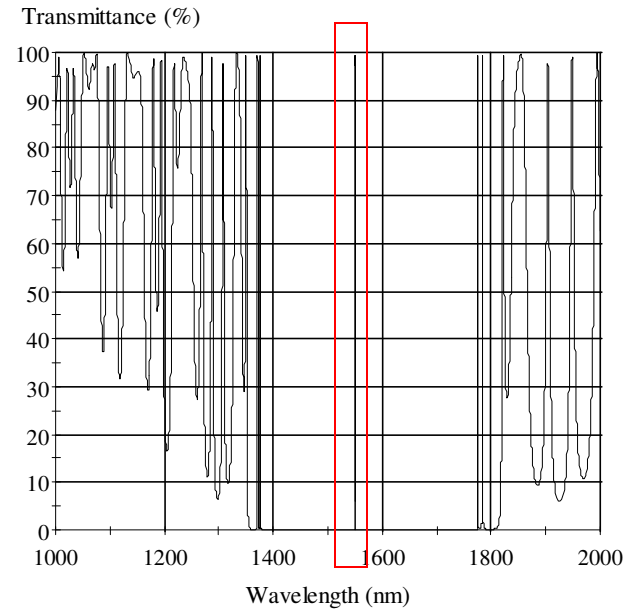


# 3 Cavity Filter

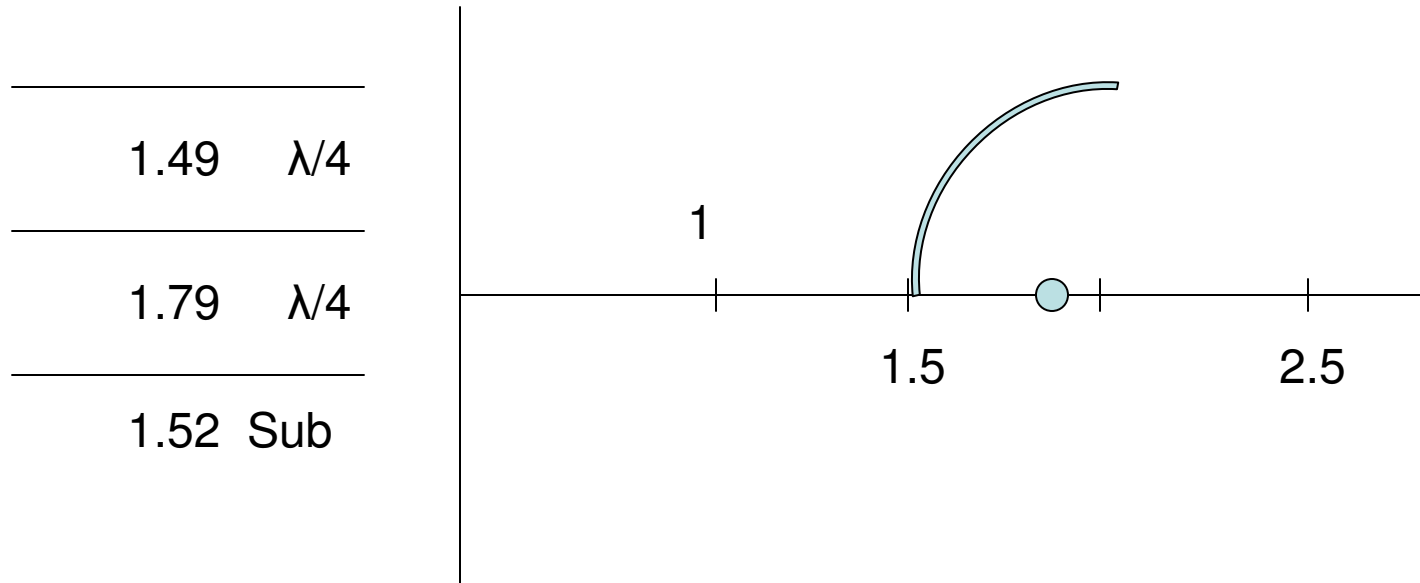
Three Cavity Narrowband Filter : Transmittance



Three Cavity Narrowband Filter : Transmittance

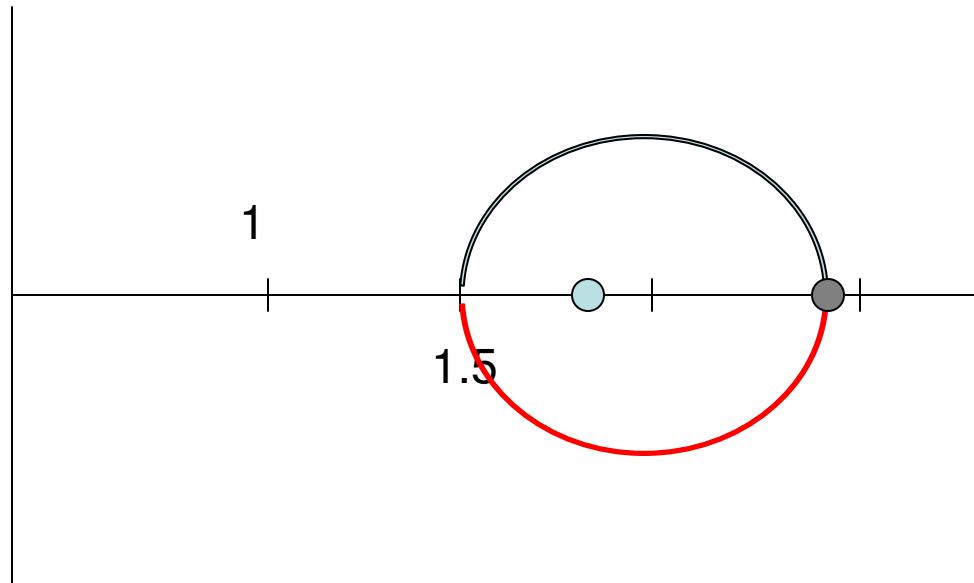


# Admittance Diagram



$$Y^2/Y_{\text{sub}} = 2.13$$

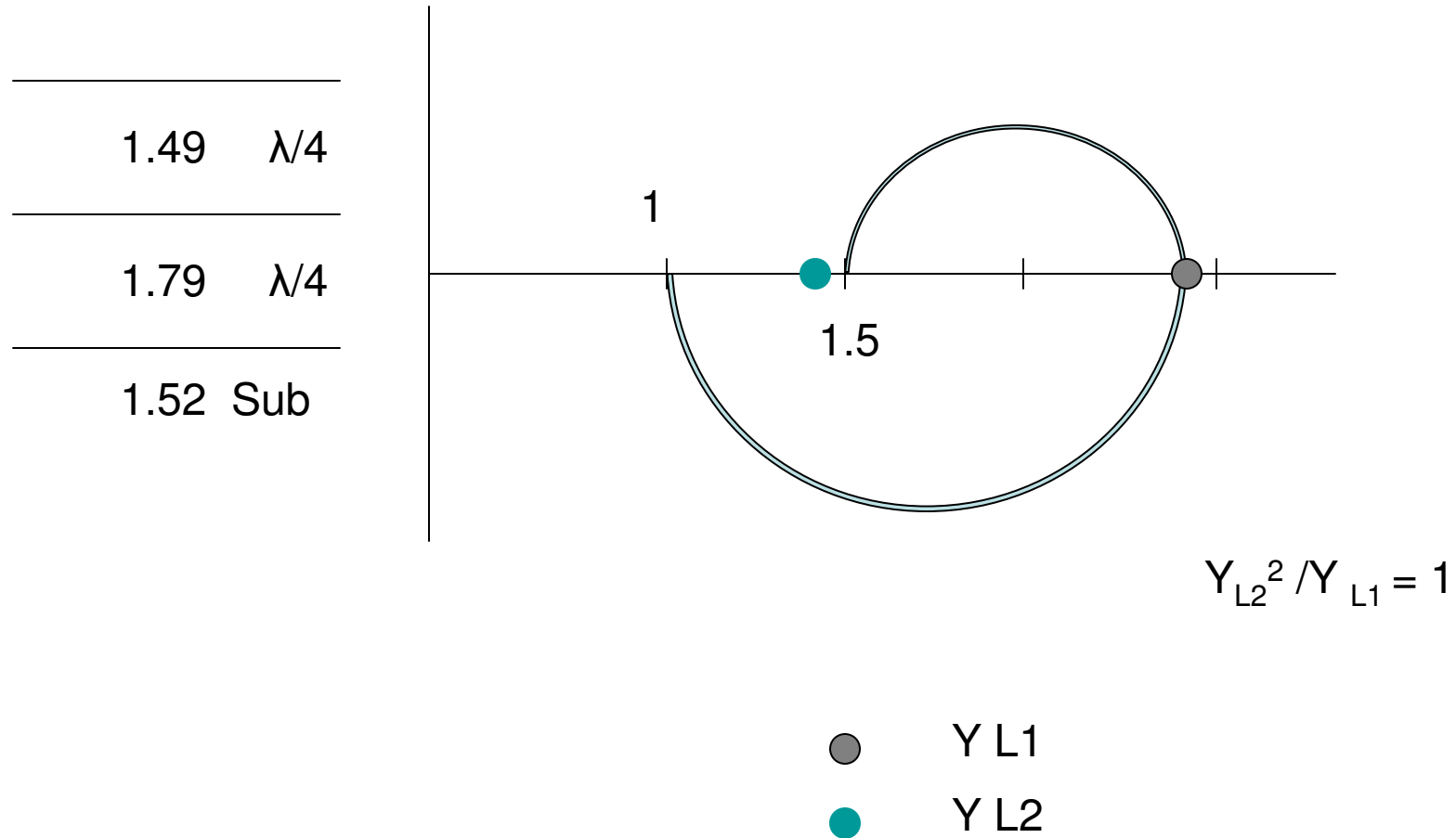
# Admittance Diagram



● High Index 1.79

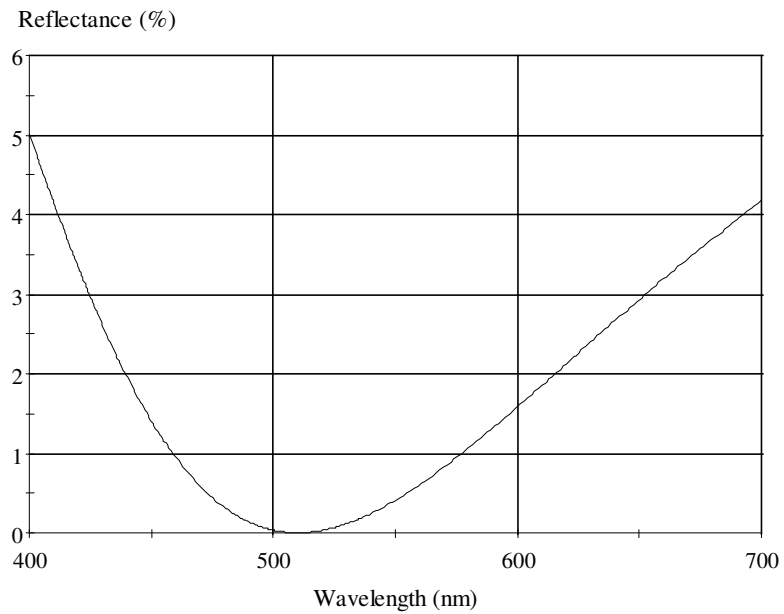
●  $Y^2/Y_{sub}$

# Admittance Diagram



# V-Coat

vcoat: Reflectance



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1.49	$\lambda/4$
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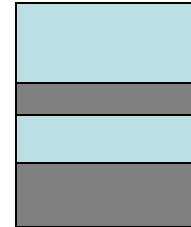
1.79	$\lambda/4$
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1.52	Sub
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# Design Space

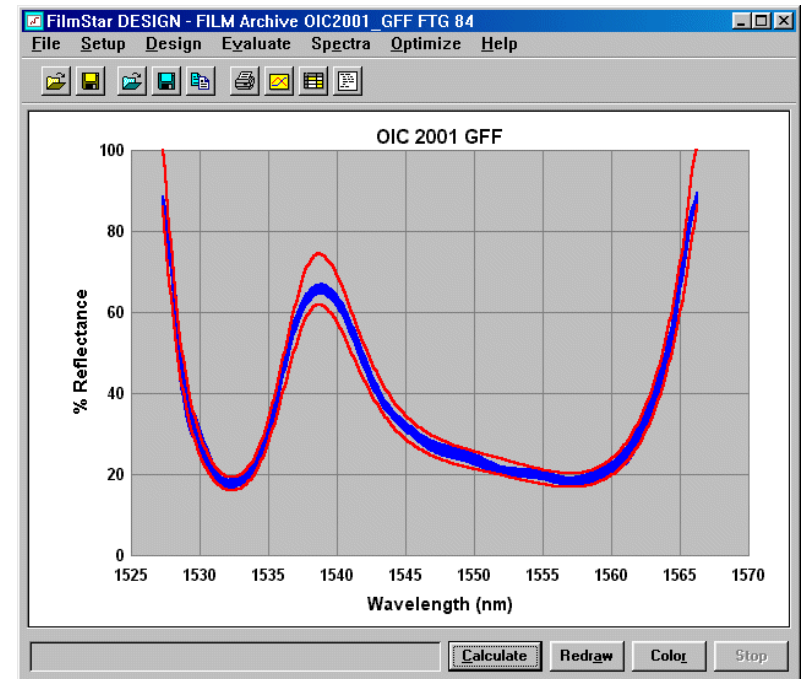
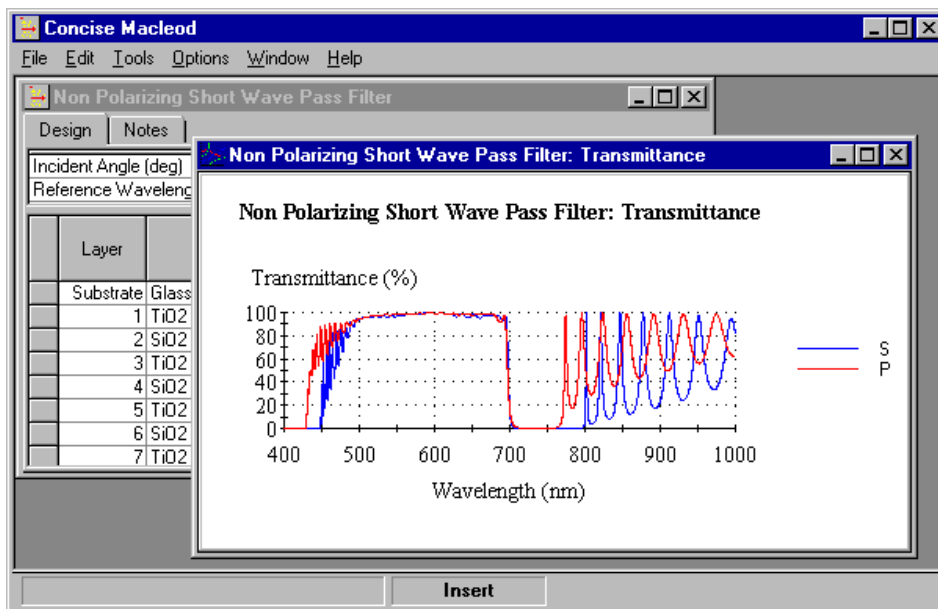
- Alternating Layers HLHLHL
  - Most Common, least Expensive
- Varying Index Discrete Layers
  - Requires Mixing or Multiple Materials
- Continuously Varying Index
  - Precision notch filters, expensive
  - Rugate Filter



# Thin Film Designs

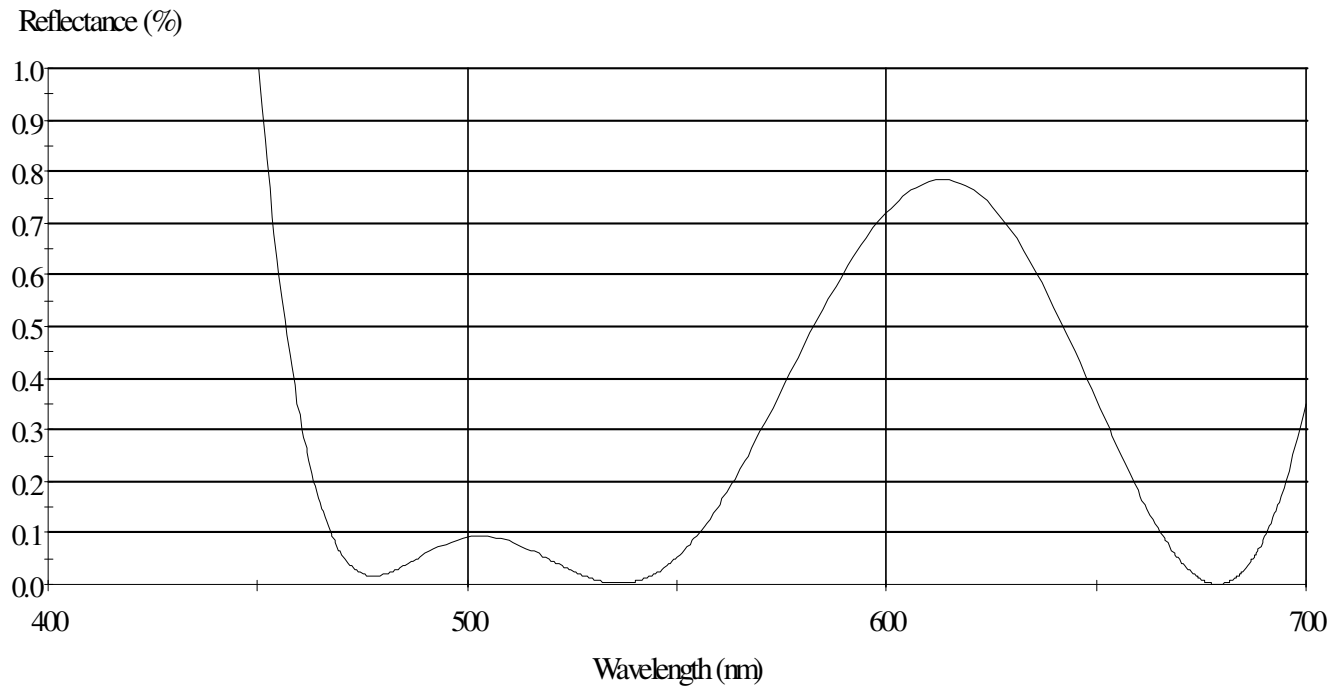
Concise Macleod  
[www.thinfilmcenter.com](http://www.thinfilmcenter.com)

FilmStar  
[www.ftgsoftware.com/](http://www.ftgsoftware.com/)



# Laser AR Coating

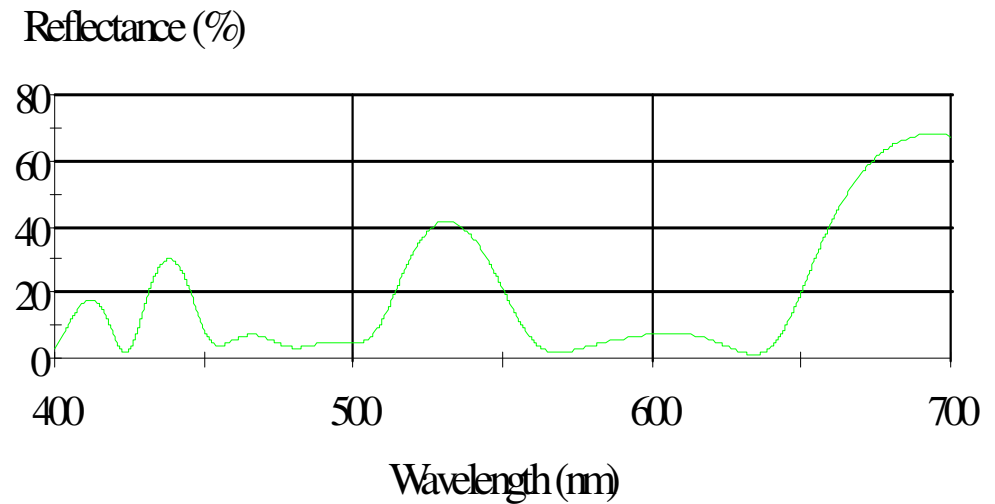
Laser AR RGB Ta<sub>2</sub>O<sub>5</sub> SiO<sub>2</sub>: Reflectance



# Dual Notch Green

green notch reflector: Reflectance

green notch reflector					
Design		Notes			
Incident Angle (deg)		45.00			
Reference Wavelength (nm)		2275.00			
	Layer	Material	Refractive Index	Extinction Coefficient	Optical Thickness (FwOT)
▶	Medium	Air	1.00000	0.00000	
	1	SiO2	1.43375	0.00000	0.17595764
	2	Ta2O5	2.10000	0.00000	0.38597036
	3	SiO2	1.43375	0.00000	0.11187794
	4	Ta2O5	2.10000	0.00000	0.39014281
	5	SiO2	1.43375	0.00000	0.23293873
	6	Ta2O5	2.10000	0.00000	0.26846544
	7	SiO2	1.43375	0.00000	0.59099627
	Substrate	Glass	1.49002	0.00000	
					2.15634919

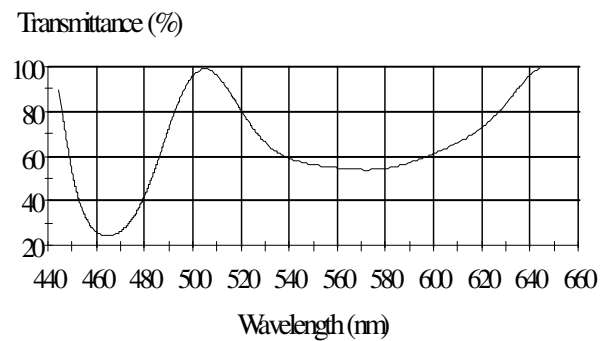


- 50% reflectance 540nm

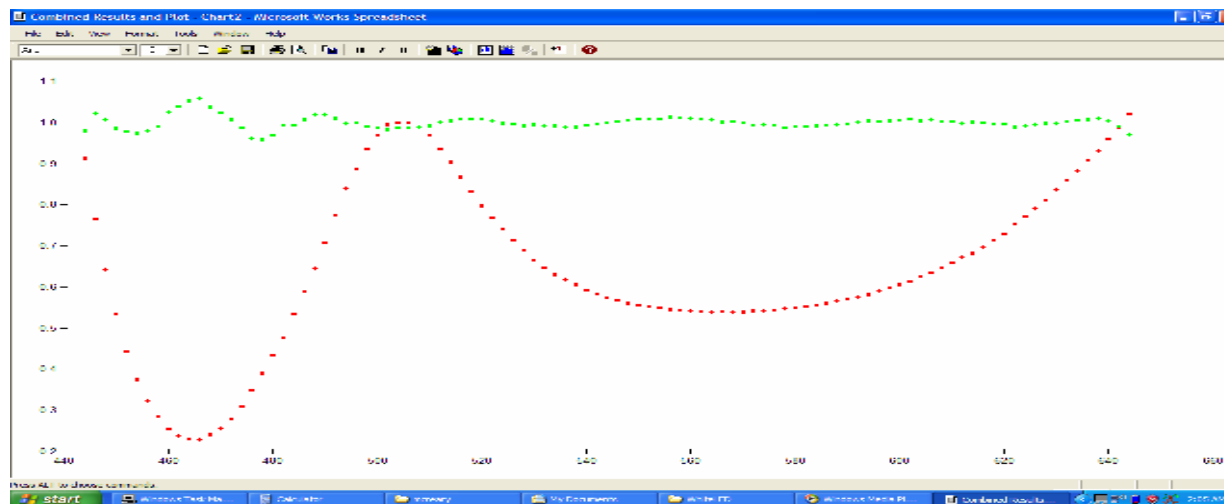
- Less than 10% (450 – 520 nm / 560 – 640 nm)

# White LED Flat Spectral

WLED18: Transmittance

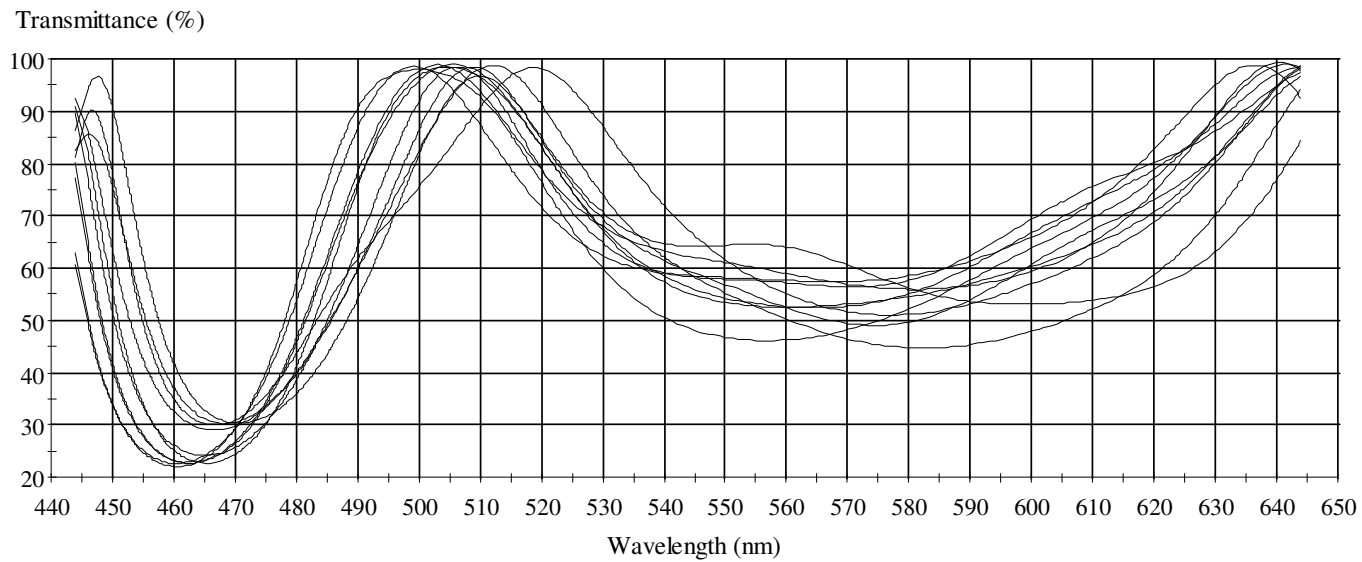


- Flat LED spectrum to  $\pm 10\%$
- Less than 20 layers



# Tolerancing

WLED18: Transmittance



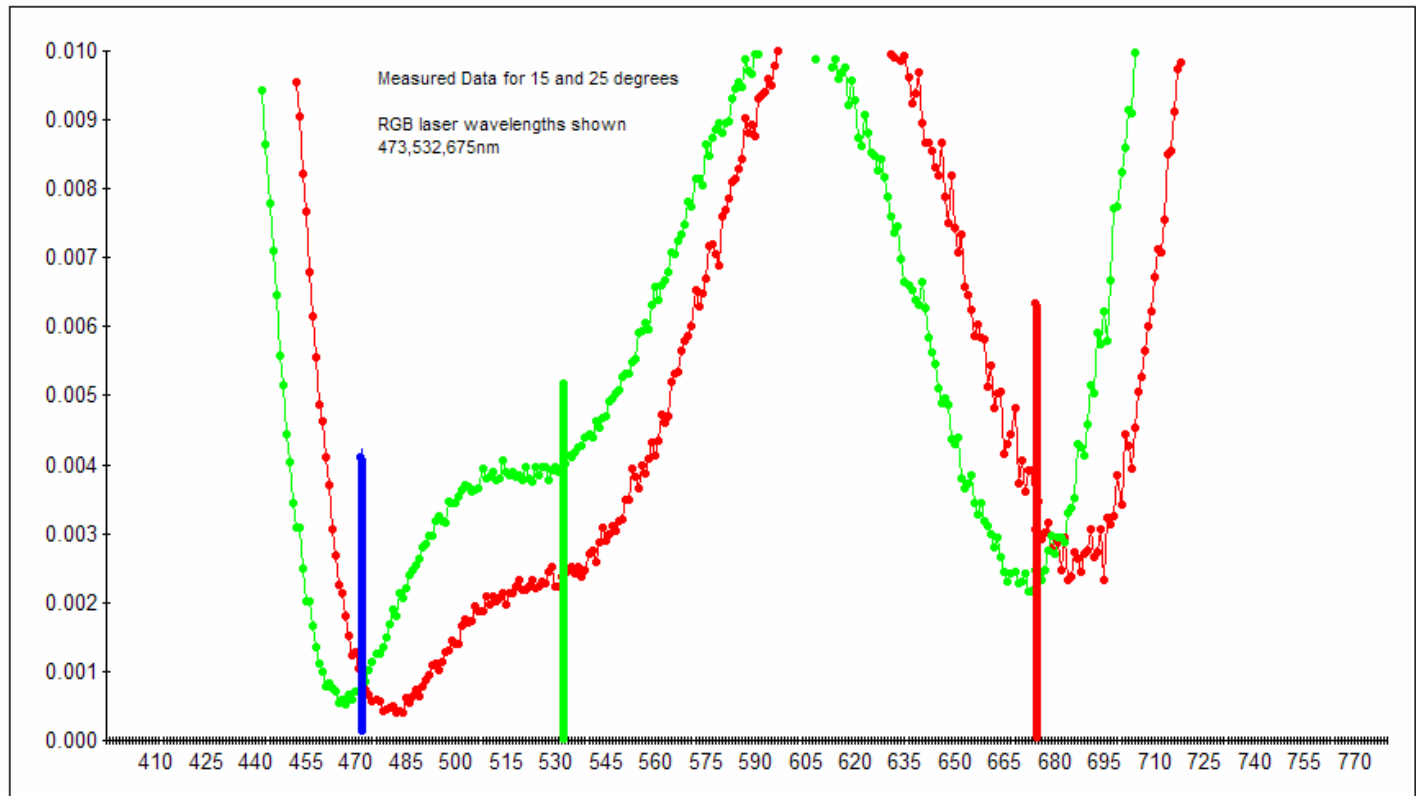
2% Thickness Variation Monte-Carlo

**Design is not Practical**

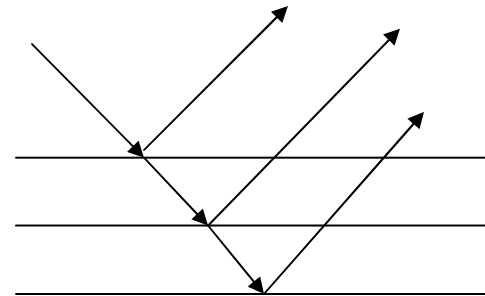
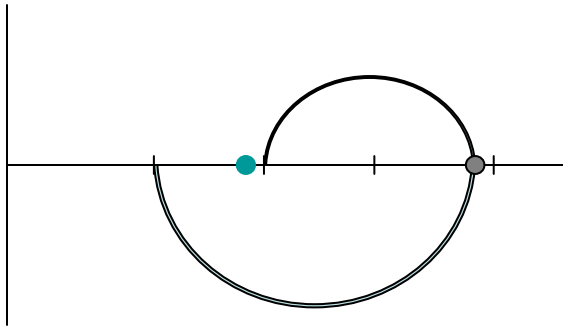
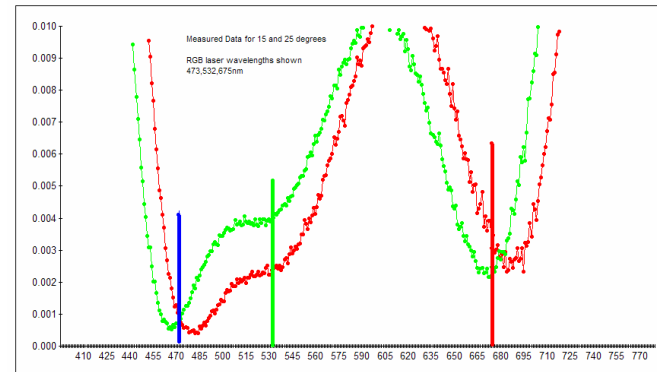
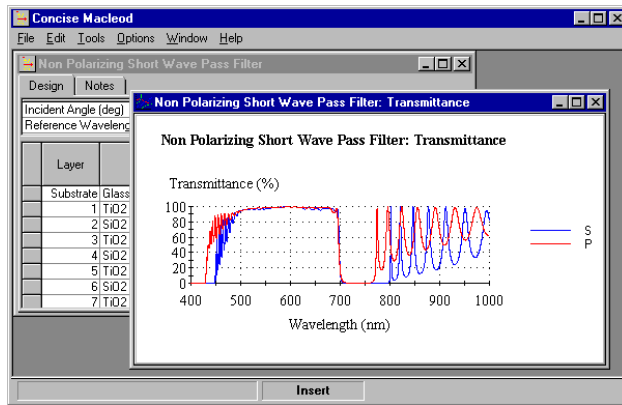
# Manufacturing

- [www.thinfilmlabs.com](http://www.thinfilmlabs.com) (Thin Film Labs)
- [www.zcrcoatings.com](http://www.zcrcoatings.com) (ZC&R)

# Laser AR Coating



# Thin Film Filters Questions?



Special Thanks to Angus Macleod