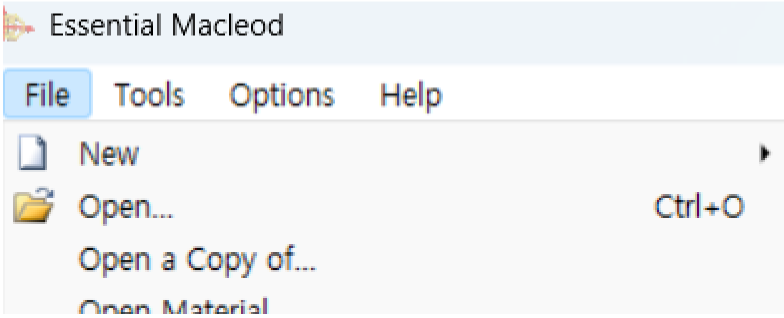
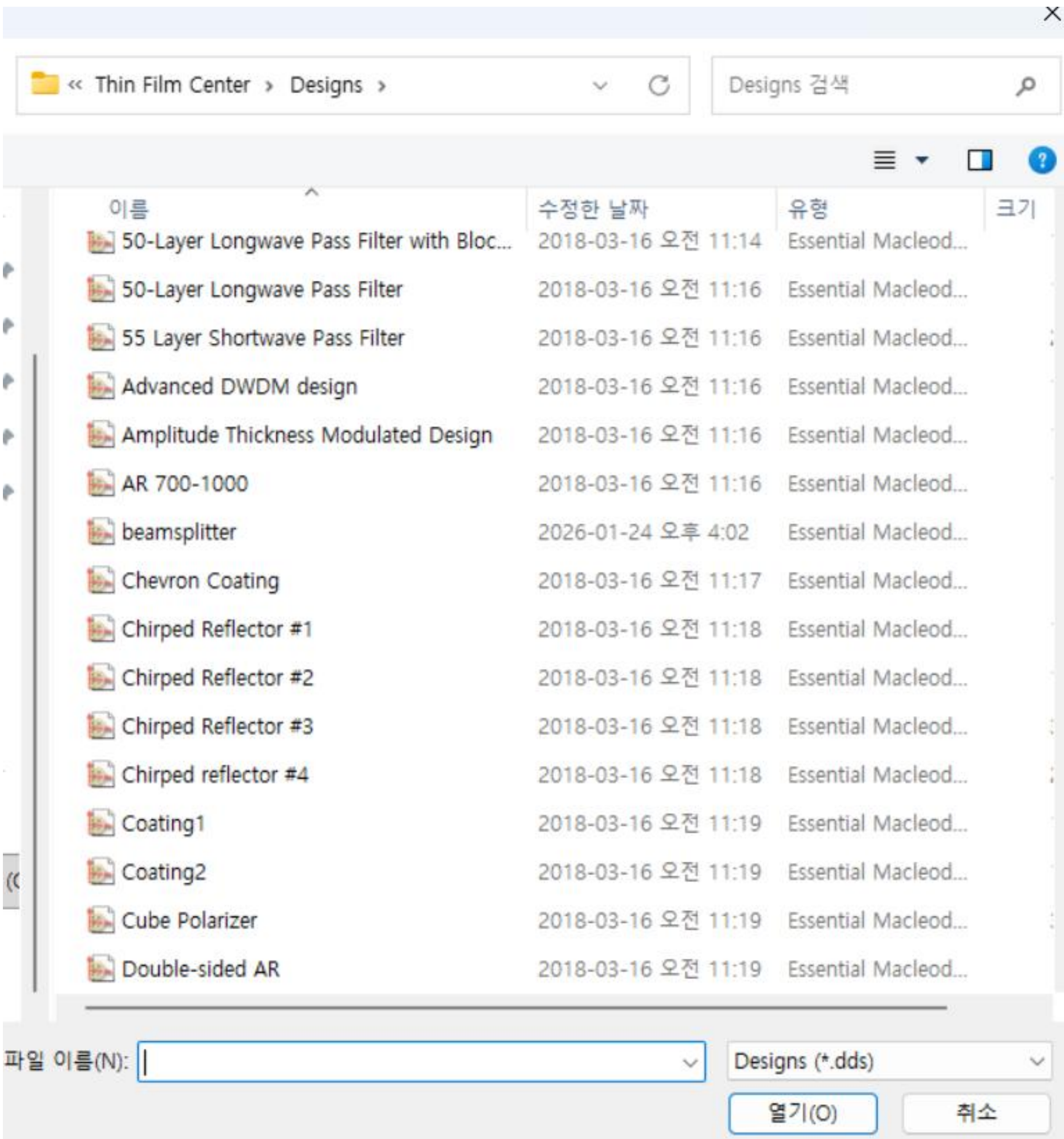
1. 기본으로 제공되는 Design File



File > Open

프로그램을 설치하면 아래 그림과 같이 Design Folder에
50개 정도의 표준 디자인 파일이 제공됩니다.



2. 주요 광학 필터 설계(예)

목　　　차

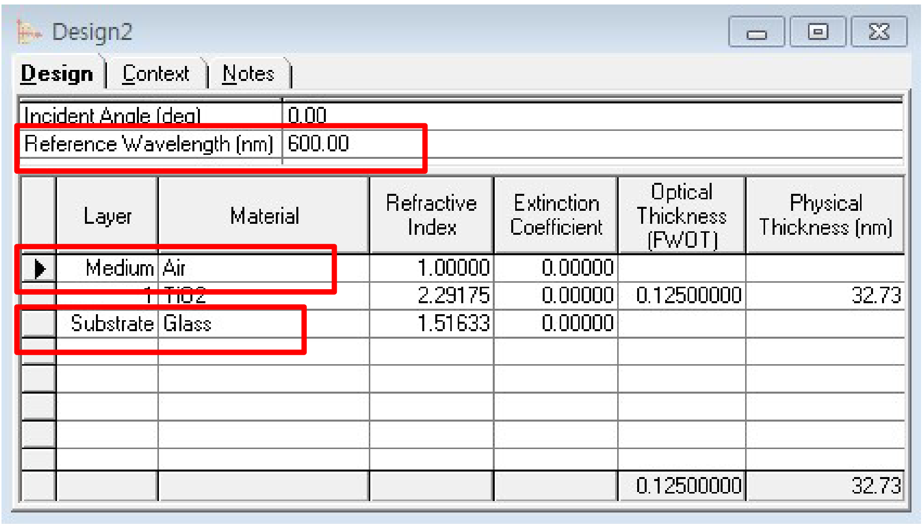
- 디자인 설정 Data 개념 이해 하기

Incident Medium: Air Substrate: Glass

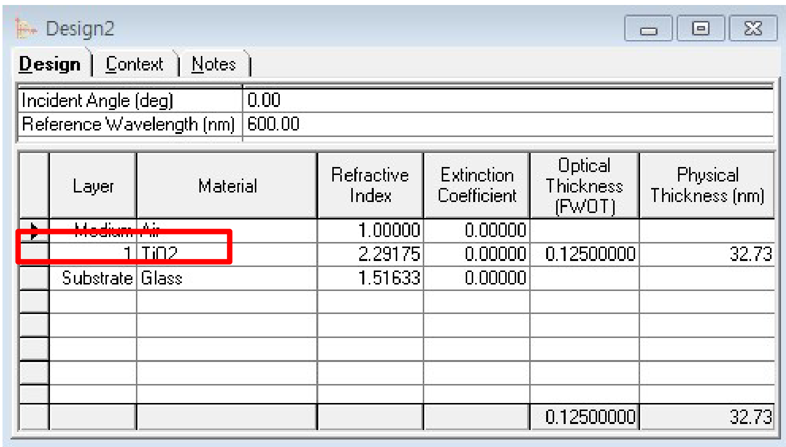
λ0: 510nm : 기준 파장 값으로 Calculation range(측정 범위)에 따라 값을 설정, 입력.

Formula : 코팅 레이어 설계를 수식으로 하는 방식

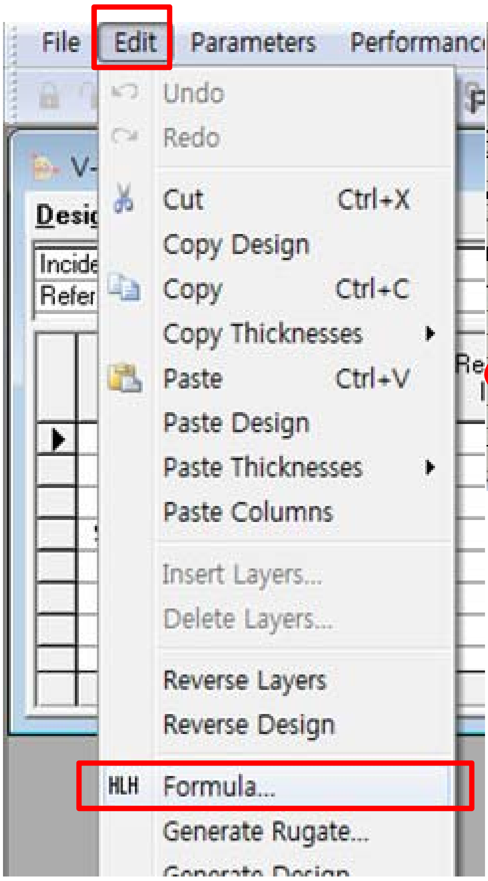
Symbol	Material	Optical Thickness (FWOT)	Physical Thickness (nm)
L	MgF2	0.25	
H	Ta2O5	0.25	
Starting Formula		Air | L 0.2H 0.2L 1.5H 0.2L 0.2H | Glass	
Calculation range		400nm 900nm	

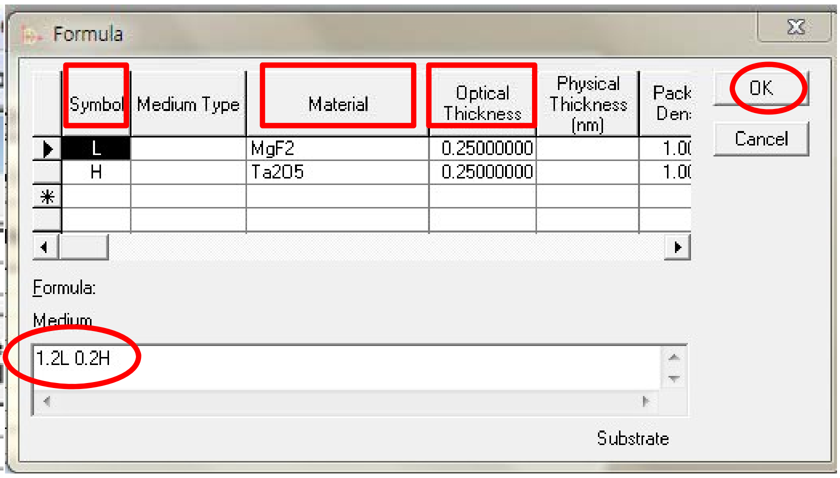


Formula : 코팅 레이어 설계를 직접 레이어에 입력하는 것이 아니라 수식으로 하는 방식.



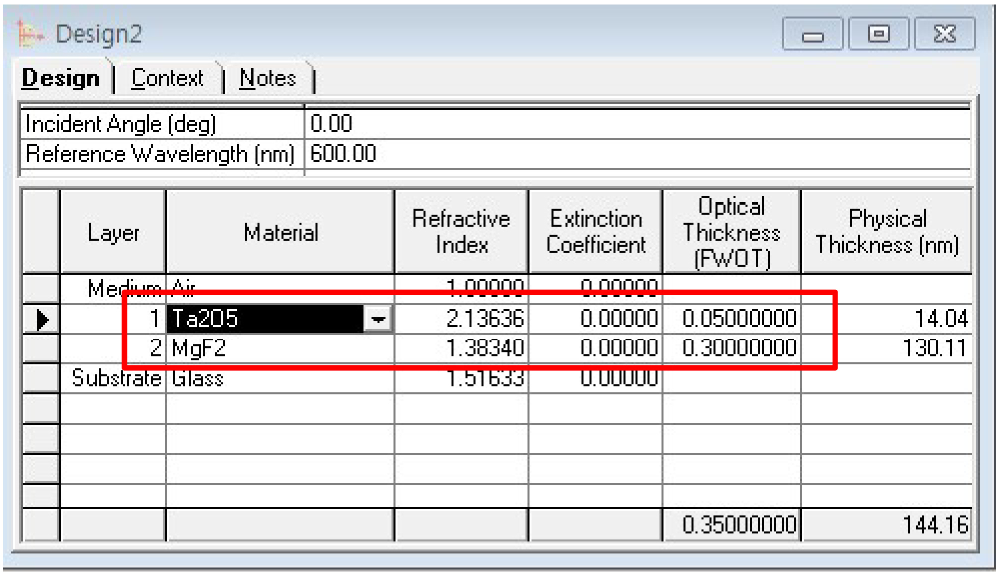
디자인 파일을 열어 놓은 상태에서.





Symbol은 키보드 입력,
Material은 탐색하여 선정,
두께는 키보드로 입력한 후
Medium에 수식을 입력한 후
"OK" 버튼을 클릭 합니다.

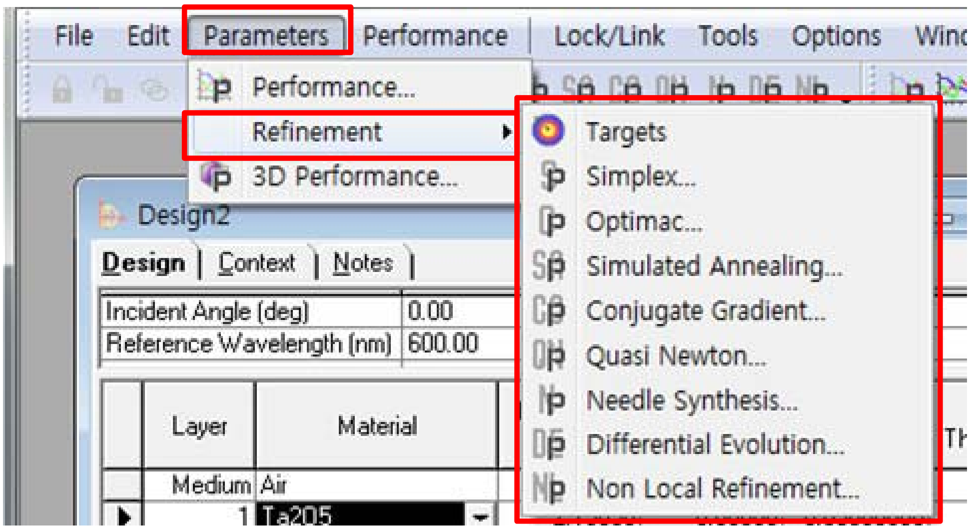
0.2H = 0.2 × 0.25 (설정 두께) = 0.05 full waves
1.2L = 1.2 × 0.25 (설정 두께) = 0.3 full waves



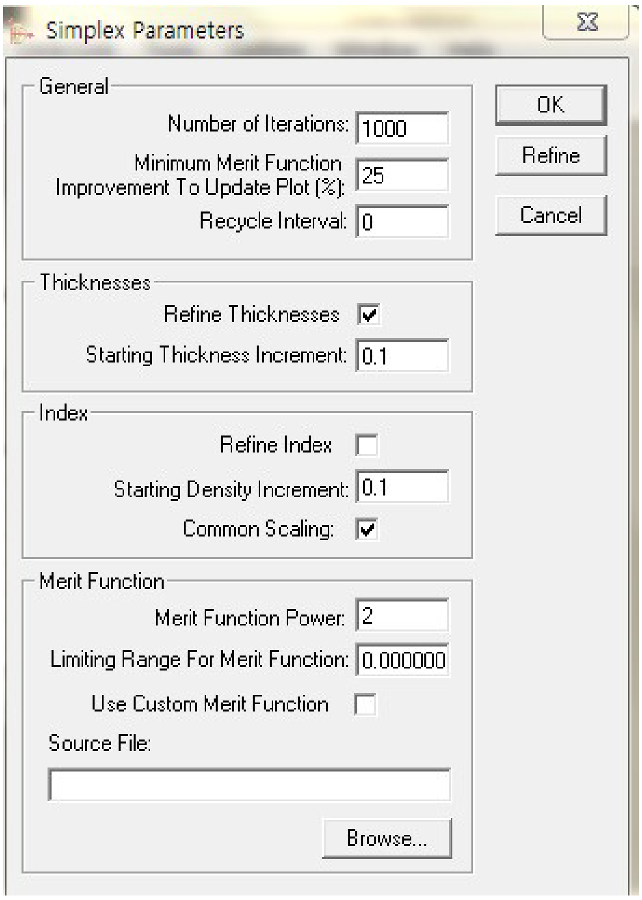
수식에 의거 물질과 두께가 수정되어 입력됨.

Starting Formula : 초기 디자인 식

Refinement



최적의 설계를 위해 적합한 Refinement 선정, 수행



Refinement 조건을 입력하고
"Refine" 버튼을 클릭하여 수행.

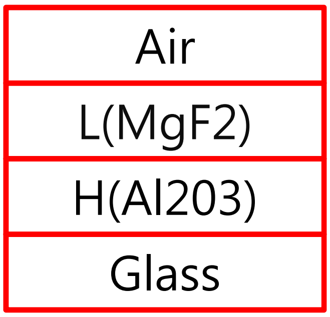
Formula , Refinement의 상세내용은 한글 매뉴얼을 참고 하세요.

1. Quarter-Quarter Antireflection Coating (1/4-1/4 비(非)반사 코팅)

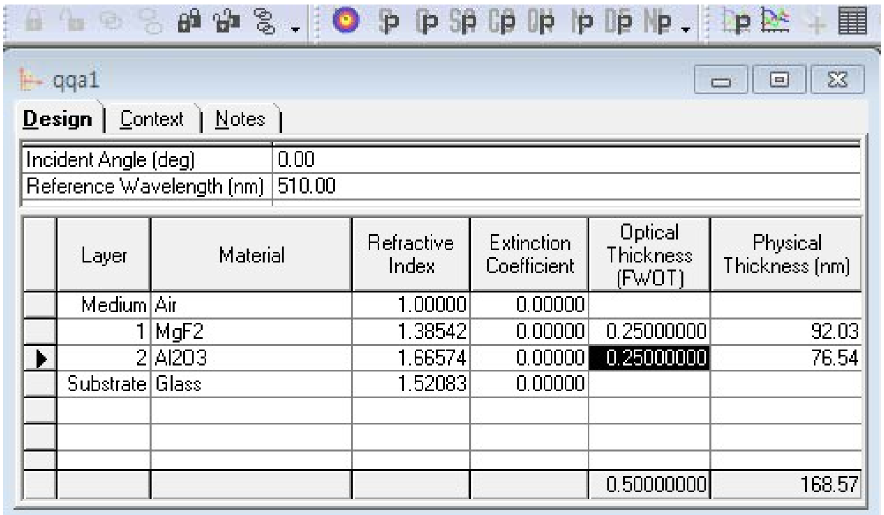
Incident Medium: Air Substrate: Glass

λ0: 510nm

Symbol	Material	Optical Thickness (FWOT)	Physical Thickness (nm)
L	MgF2	0.25	
H	Al2O3	0.25	
Starting Formula		Air | L H | Glass	
Calculation range		400nm 700nm	

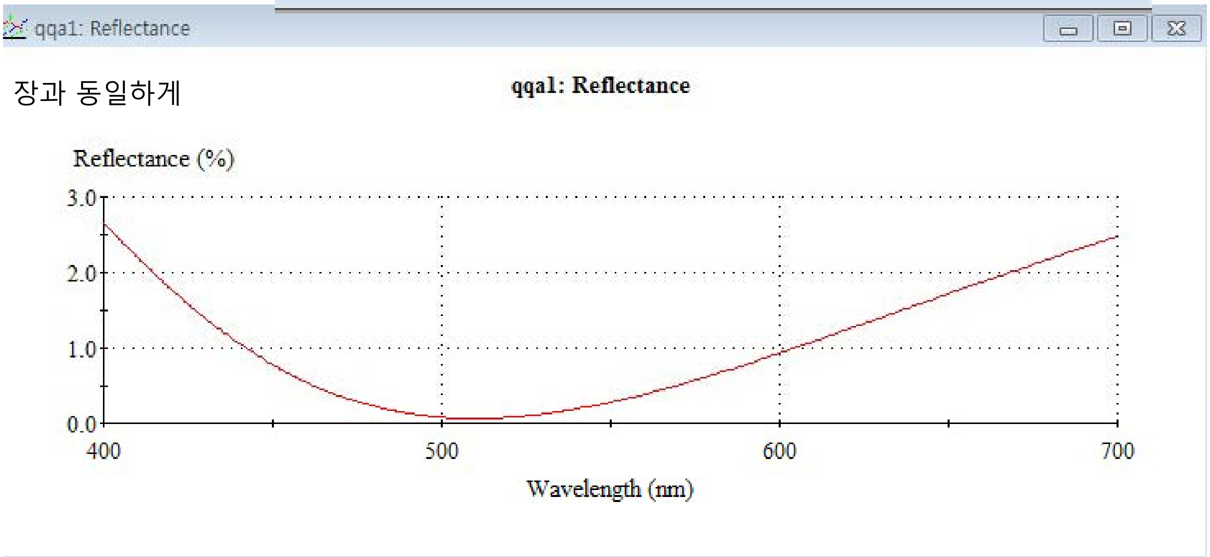


File > New > Design



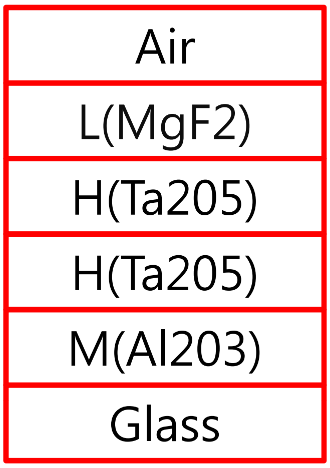
Parameters > Performance

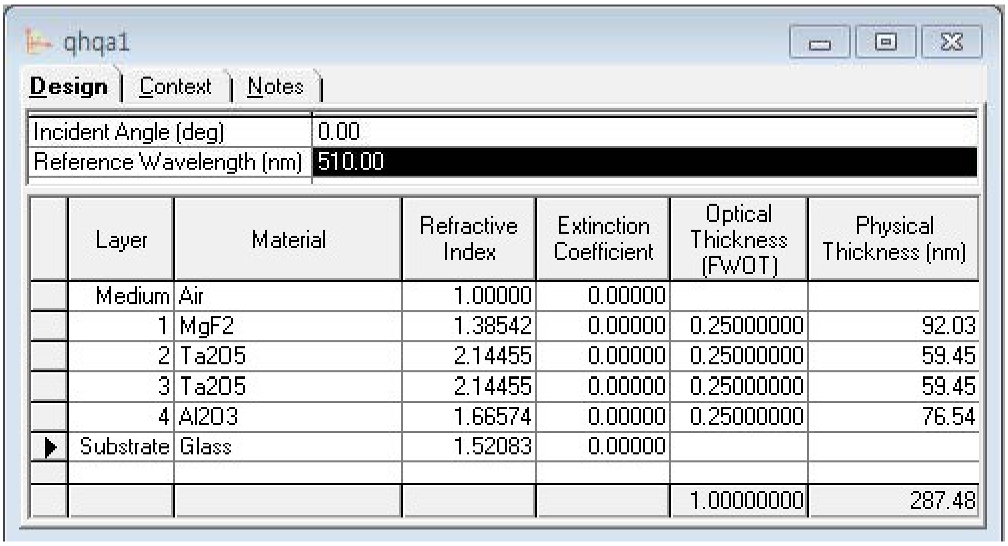
전 장과 동일하게



2. Quarter Half Quarter Antireflection Coating (1/4-1/2-1/4 비(非)반사 코팅)

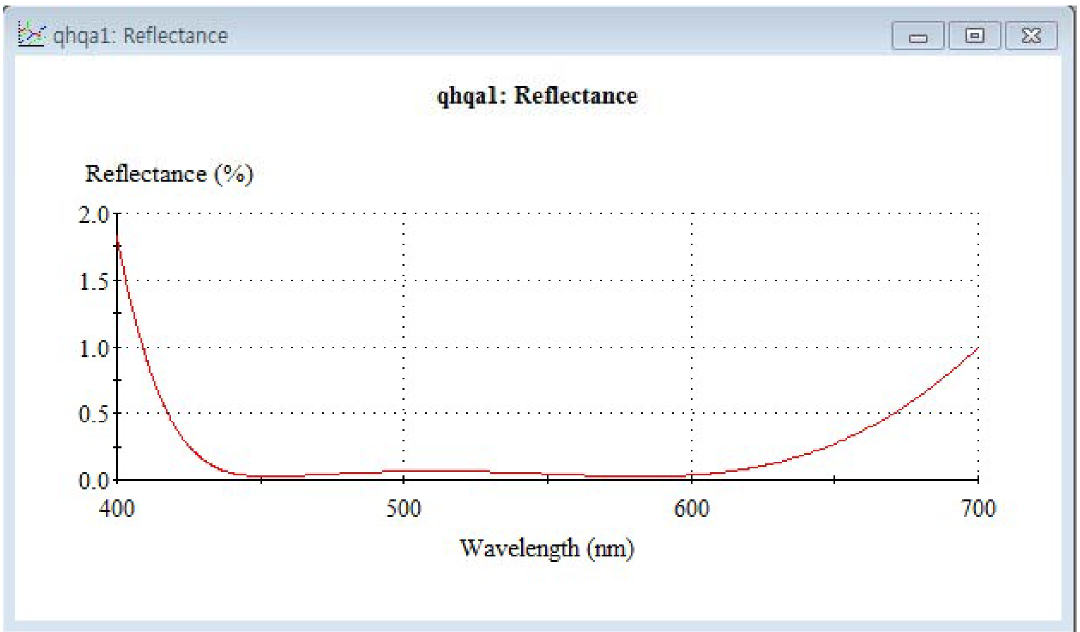
Incident Medium: Air		Substrate: Glass	
λ0: 510nm			
Symbol	Material	Optical Thickness (FWOT)	Physical Thickness (nm)
L	MgF2	0.25	
M	Al2O3	0.25	
H	Ta2O5	0.25	
Starting Formula		Air | L HH M | Glass	
Calculation range		400nm 700nm	





Incident Angle (deg)	0.00
Reference Wavelength (nm)	510.00

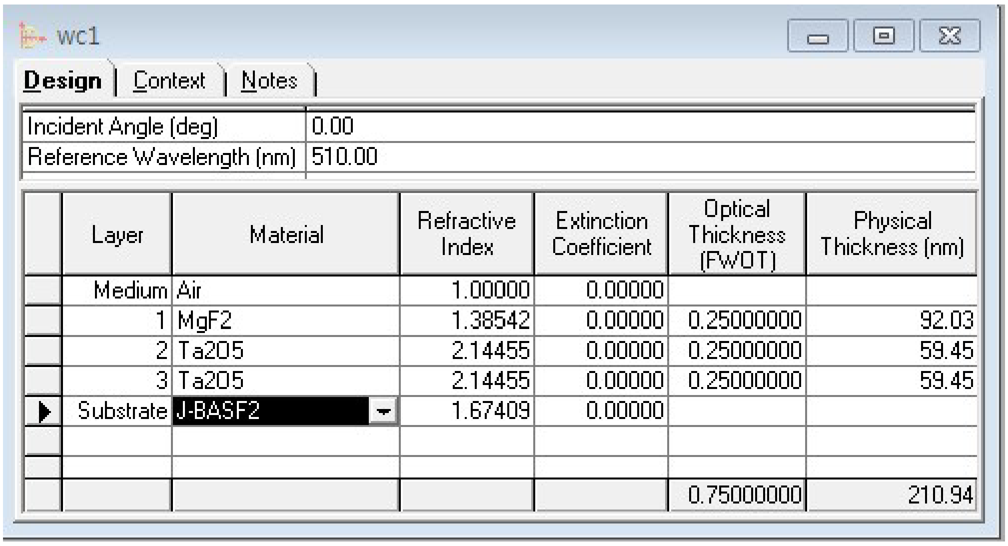
Layer	Material	Refractive Index	Extinction Coefficient	Optical Thickness (FWOT)	Physical Thickness (nm)
Medium	Air	1.00000	0.00000		
1	MgF2	1.38542	0.00000	0.25000000	92.03
2	Ta205	2.14455	0.00000	0.25000000	59.45
3	Ta205	2.14455	0.00000	0.25000000	59.45
4	Al2O3	1.66574	0.00000	0.25000000	76.54
Substrate	Glass	1.52083	0.00000		
				1.00000000	287.48



3. W-Coating (Wing Coating)

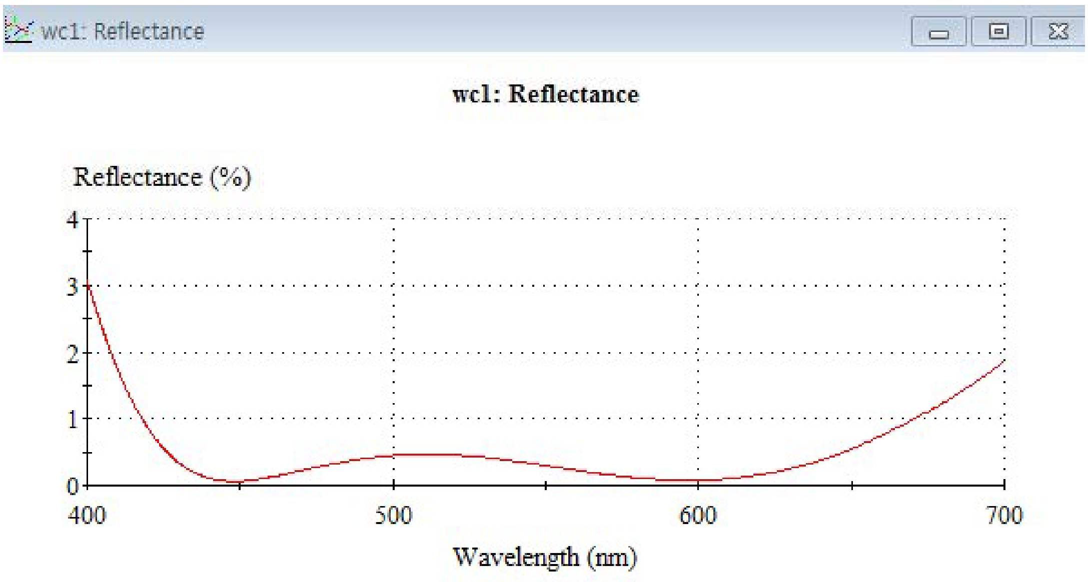
W-coat는 크라운 보다는 플린트 유리에 주로 사용됩니다

Incident Medium: Air		Substrate: BaSF 1 Glass	
λ0: 510nm			
Symbol	Material	Optical Thickness (FWOT)	Physical Thickness (nm)
L	MgF2	0.25	
H	Ta2O5	0.25	
Starting Formula		Air | L HH | BaSF 1	
Calculation range		400nm	700nm



Incident Angle (deg)	0.00
Reference Wavelength (nm)	510.00

Layer	Material	Refractive Index	Extinction Coefficient	Optical Thickness (FWOT)	Physical Thickness (nm)
Medium	Air	1.00000	0.00000		
1	MgF2	1.38542	0.00000	0.25000000	92.03
2	Ta2O5	2.14455	0.00000	0.25000000	59.45
3	Ta2O5	2.14455	0.00000	0.25000000	59.45
Substrate	J-BASF2	1.67409	0.00000		
				0.75000000	210.94



4. V-Coating

이론적으로 특정 파장 대에 반사율을 “0”으로 하는 디자인.

Incident Medium: Air Substrate: Glass

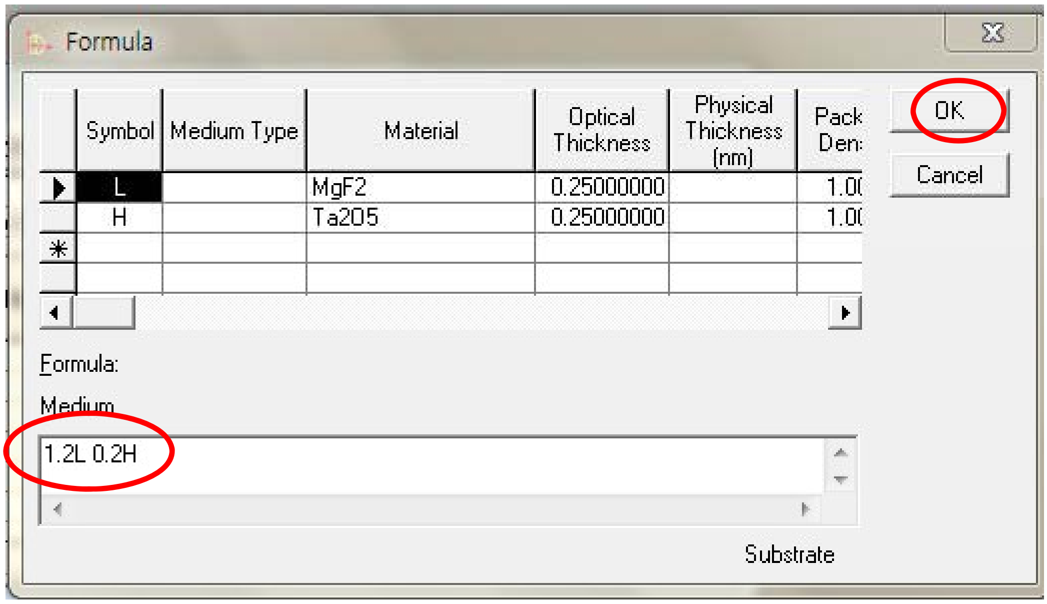
λ0: 510nm

Symbol	Material	Optical Thickness (FWOT)	Physical Thickness (nm)
L	MgF2	0.25	
H	Ta2O5	0.25	
Starting Formula		Air | 1.2L 0.2H | Glass	
Calculation range		400nm	700nm

File > New > Design

하나의 디자인 창을 만들어 놓고

Edit > Formula



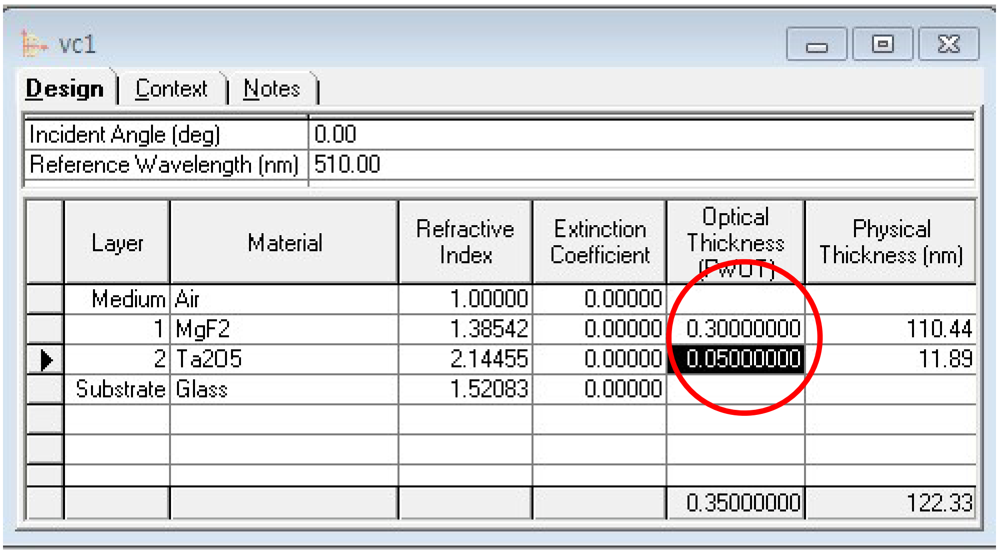
Formula

Symbol은 키보드 입력, Material은 탐색하여 선정, 두께는 키보드로 입력한 후 Medium에 수식을 입력한 후 “OK” 버튼을 클릭 합니다.

0.2H = 0.2 × 0.25 (설정 두께) = 0.05 full waves

1.2L = 1.2 × 0.25 (설정 두께) = 0.3 full waves

아래와 같이 수식대로 변경된 디자인 파일이 생성 됩니다.

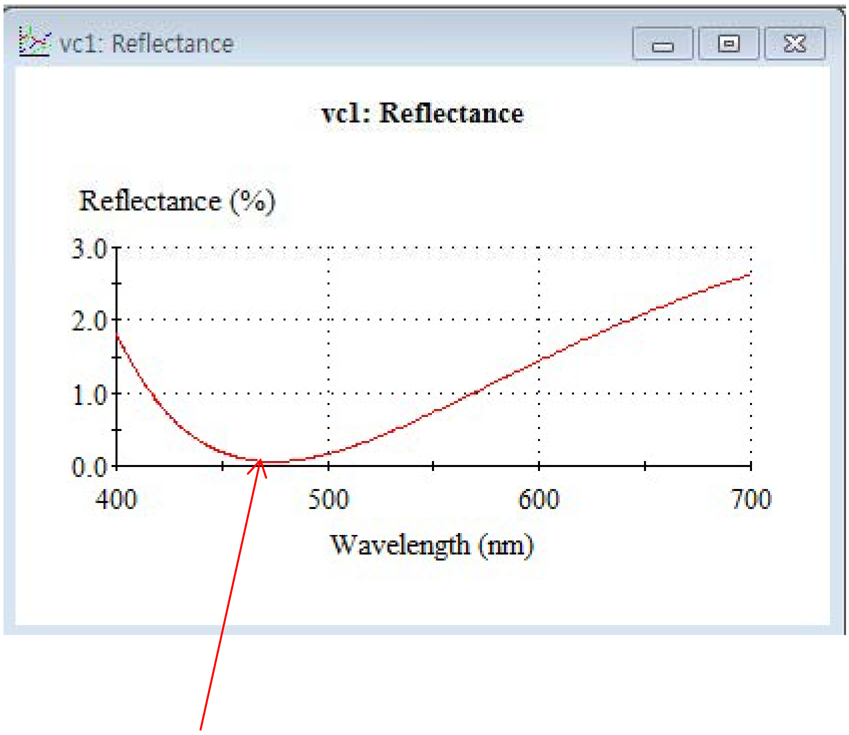


vc1

Design | Context | Notes

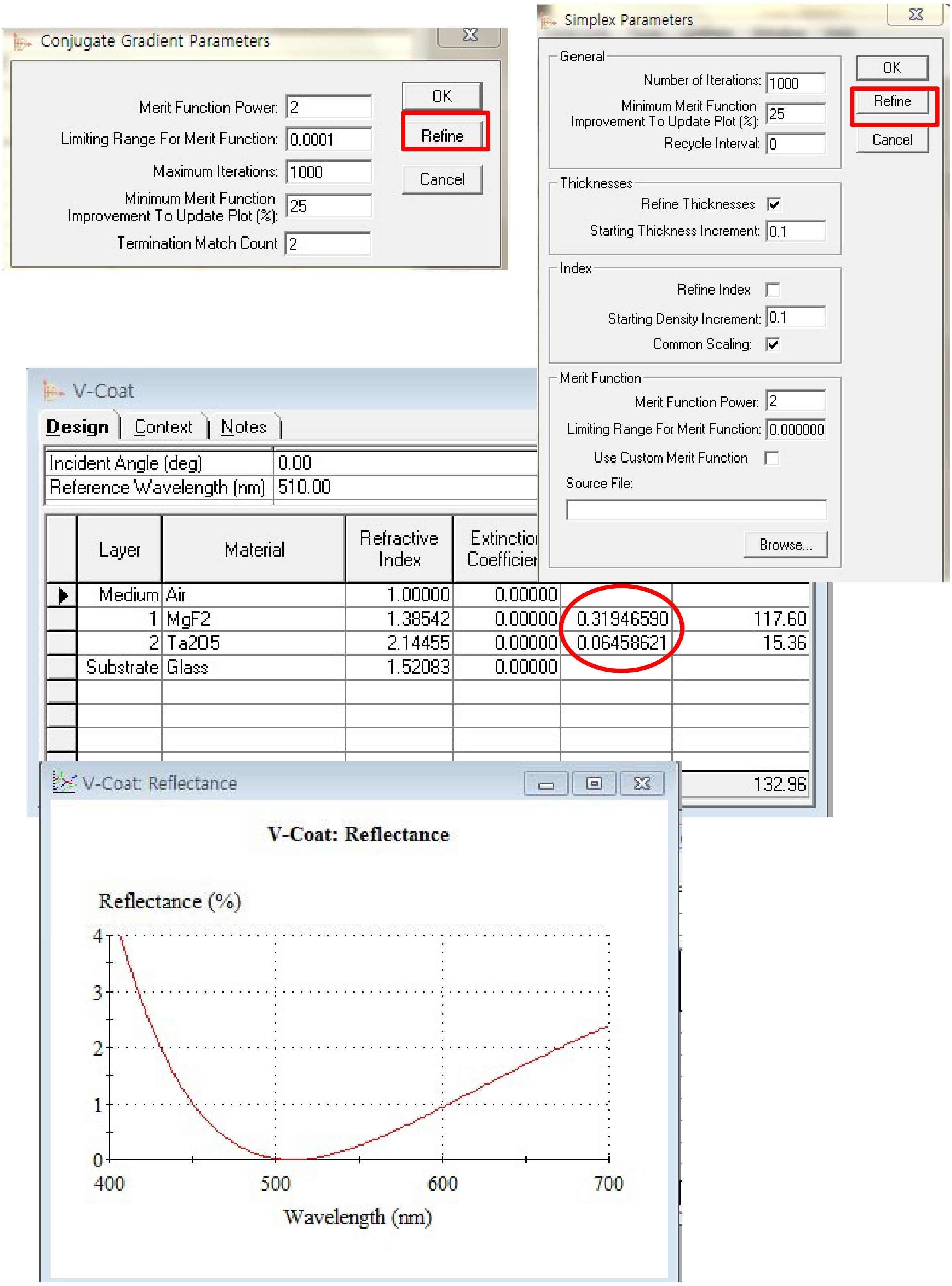
Incident Angle (deg)	0.00
Reference Wavelength (nm)	510.00

Layer	Material	Refractive Index	Extinction Coefficient	Optical Thickness (FWOT)	Physical Thickness (nm)
Medium	Air	1.00000	0.00000		
1	MgF2	1.38542	0.00000	0.30000000	110.44
2	Ta2O5	2.14455	0.00000	0.05000000	11.89
Substrate	Glass	1.52083	0.00000		
				0.35000000	122.33



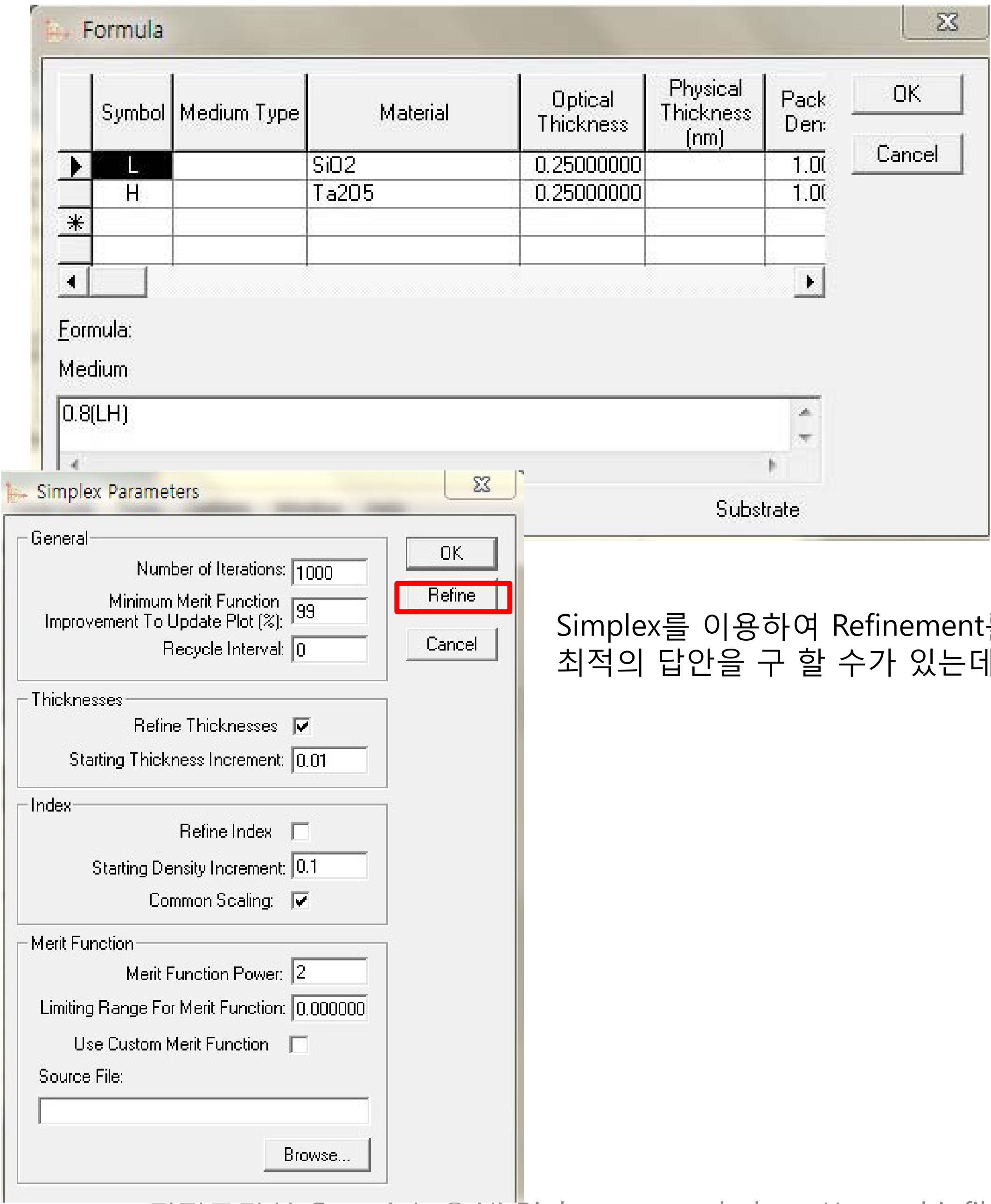
반사율 ≒ "0"

Simplex 또는 Conjugate Gradient를 이용하여 Refinement를 하면
최적의 답안을 구 할 수가 있는데 실행하면

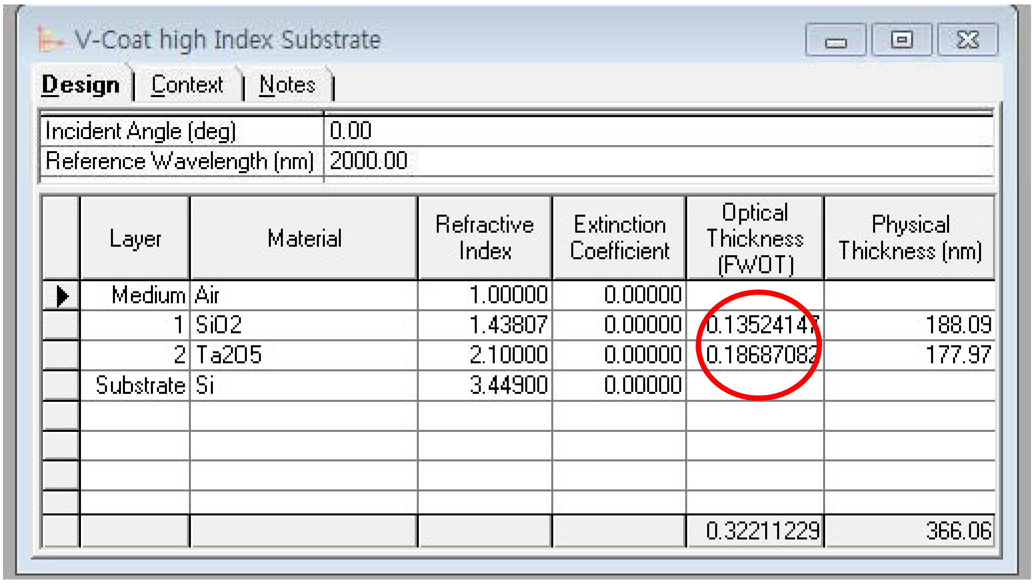


5. V-Coat High Index Substrate

Incident Medium: Air		Substrate: Silicon	
λ0: 2000nm			
Symbol	Material	Optical Thickness (FWOT)	Physical Thickness (nm)
L	SiO_2	0.25	
H	Ta_2O_5	0.25	
Starting Formula		Air | 0.8(L H) | Si	
Calculation range		1500nm 2500nm	



Simplex를 이용하여 Refinement를 하여 최적의 답안을 구 할 수가 있는데



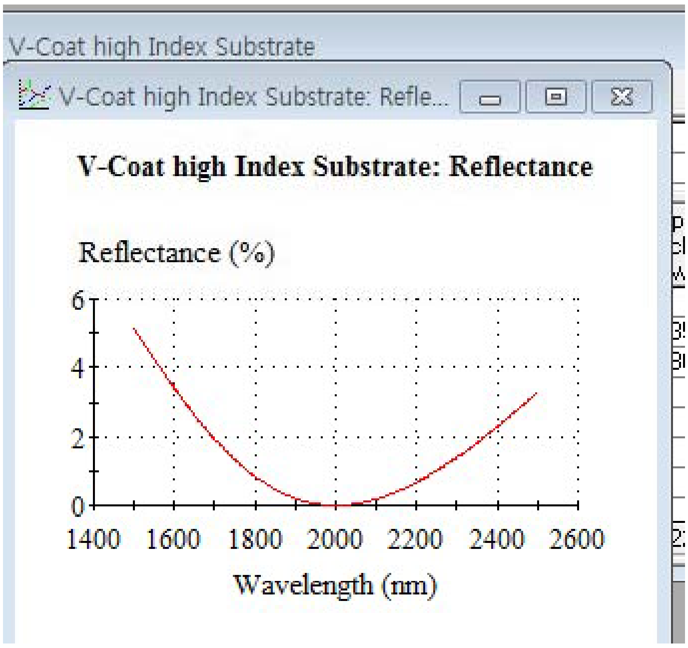
V-Coat high Index Substrate

Design | Context | Notes

Incident Angle (deg)	0.00
Reference Wavelength (nm)	2000.00

Layer	Material	Refractive Index	Extinction Coefficient	Optical Thickness (FWOT)	Physical Thickness (nm)
Medium	Air	1.00000	0.00000		
1	SiO2	1.43807	0.00000	0.13524147	188.09
2	Ta2O5	2.10000	0.00000	0.18687082	177.97
Substrate	Si	3.44900	0.00000		
				0.32211229	366.06

디자인의 물질 두께가 최적의 상태로 변경됩니다.



두 물질 모두 substrate의 굴절률 보다 작으므로 이 것은 Zero에 대한 두께가 모두 ¼파 보다 작은 곳에 있게 된다는 것을 의미 합니다.

6. Quarter Quarter for High Index Substrate

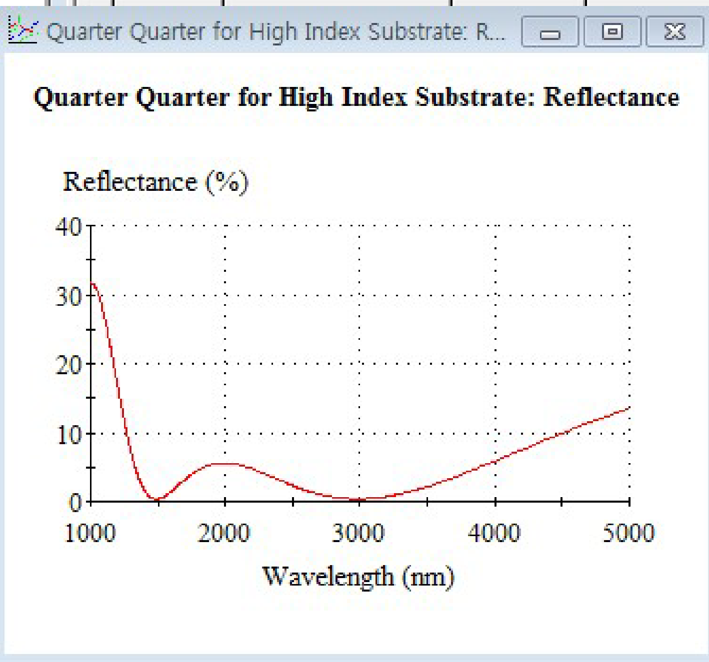
Incident Medium: Air		Substrate: Silicon	
λ0: 2000nm			
Symbol	Material	Optical Thickness (FWOT)	Physical Thickness (nm)
L	SiO_2	0.25	
H	Ta_2O_5	0.25	
Starting Formula		Air | L H | Si	
Calculation range		1000nm 5000nm	

Quarter Quarter for High Index Substrate

Design | Context | Notes

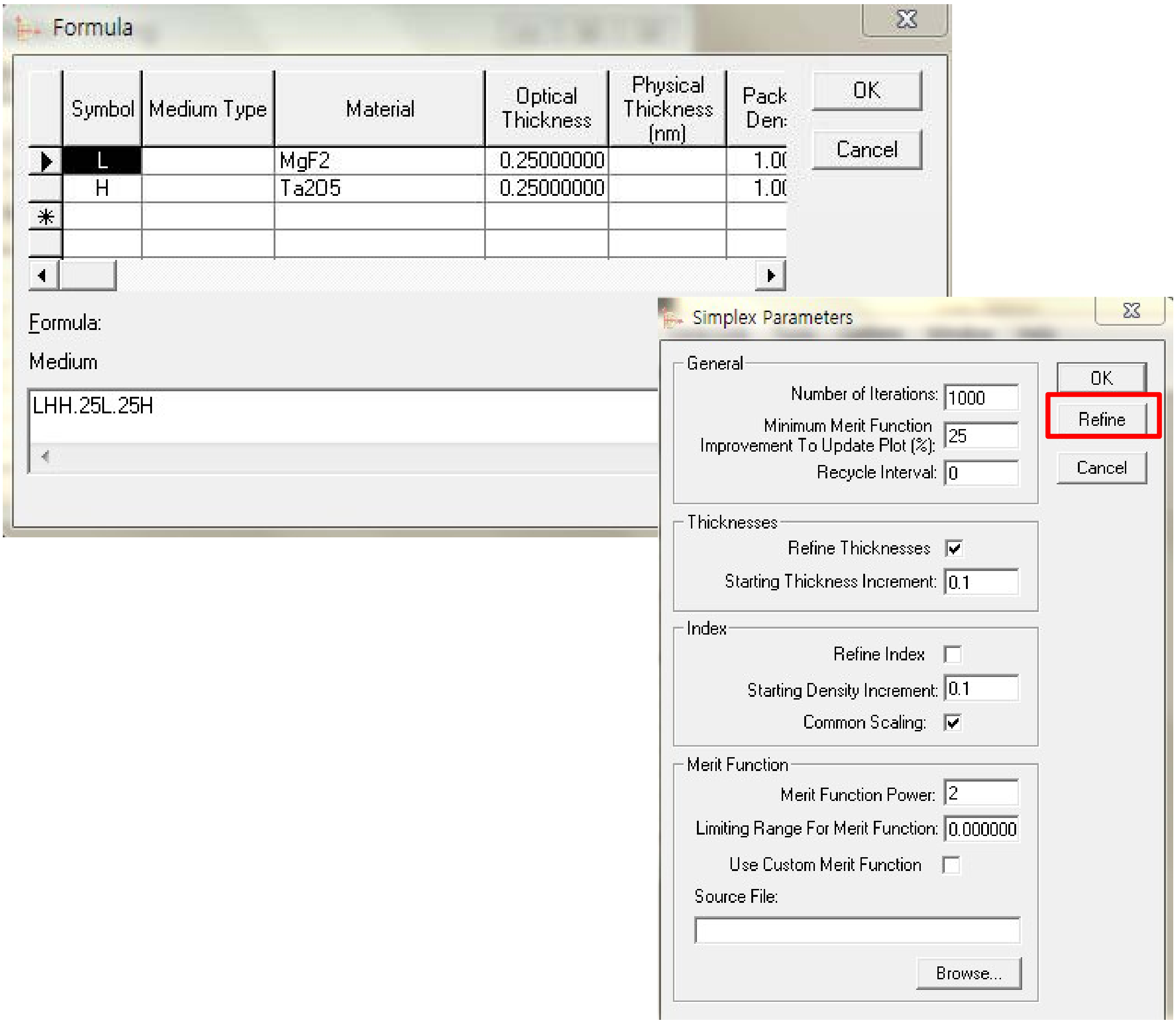
Incident Angle (deg)	0.00
Reference Wavelength (nm)	2000.00

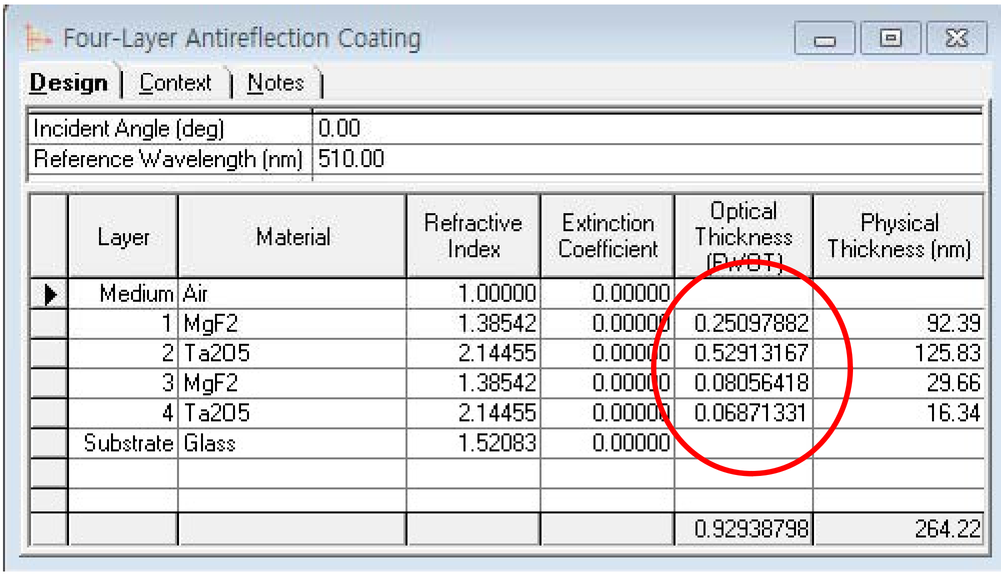
Layer	Material	Refractive Index	Extinction Coefficient	Optical Thickness (FWOT)	Physical Thickness (nm)
Medium	Air	1.00000	0.00000		
1	SiO2	1.43807	0.00000	0.25000001	347.69
2	Ta2O5	2.10000	0.00000	0.25000000	238.10
Substrate	Si	3.44900	0.00000		
				0.50000001	585.78



7. Four-Layer Antireflection Coating

Incident Medium: Air		Substrate: Glass	
λ0: 510nm			
Symbol	Material	Optical Thickness (FWOT)	Physical Thickness (nm)
L	MgF2	0.25	
H	Ta2O5	0.25	
Starting Formula		Air | LHH 0.25L 0.25H | Glass	
Calculation range		400nm 700nm	



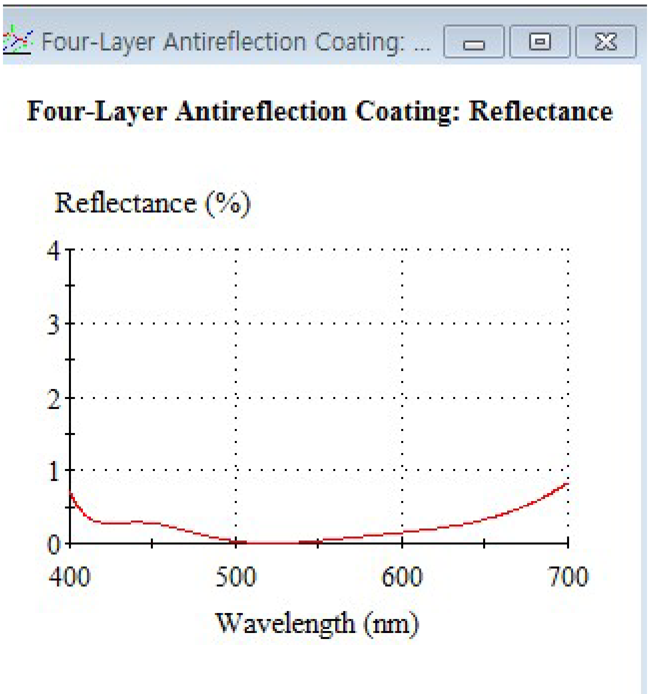


Four-Layer Antireflection Coating

Design | Context | Notes

Incident Angle (deg)	0.00
Reference Wavelength (nm)	510.00

Layer	Material	Refractive Index	Extinction Coefficient	Optical Thickness (FWOT)	Physical Thickness (nm)
Medium	Air	1.00000	0.00000		
1	MgF2	1.38542	0.00000	0.25097882	92.39
2	Ta2O5	2.14455	0.00000	0.52913167	125.83
3	MgF2	1.38542	0.00000	0.08056418	29.66
4	Ta2O5	2.14455	0.00000	0.06871331	16.34
Substrate	Glass	1.52083	0.00000		
				0.92938798	264.22



8. Broad Band Six Layer Antireflection Coating

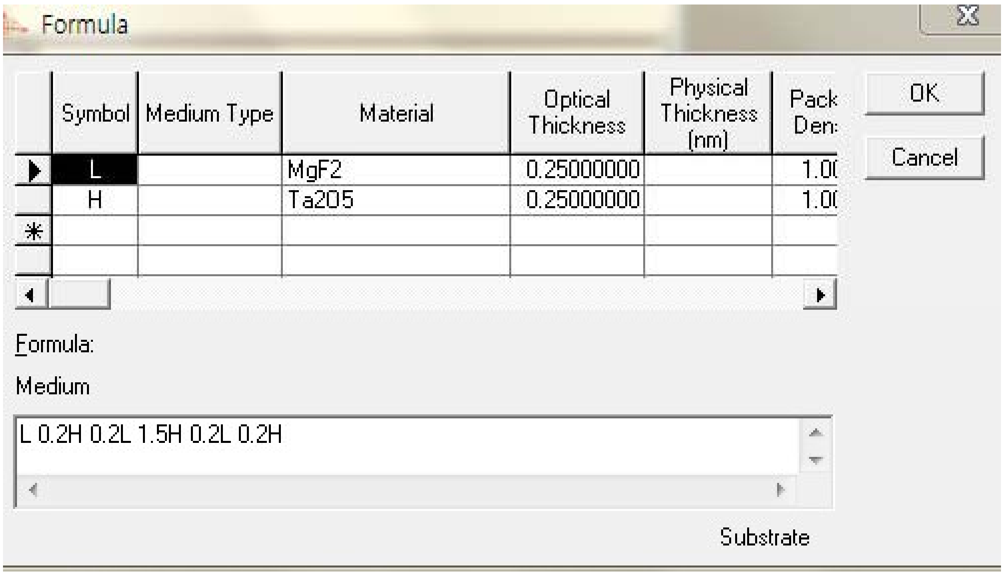
Incident Medium: Air　　Substrate: Glass

λ0: 510nm

Symbol	Material	Optical Thickness (FWOT)	Physical Thickness (nm)
L	MgF2	0.25	
H	Ta2O5	0.25	

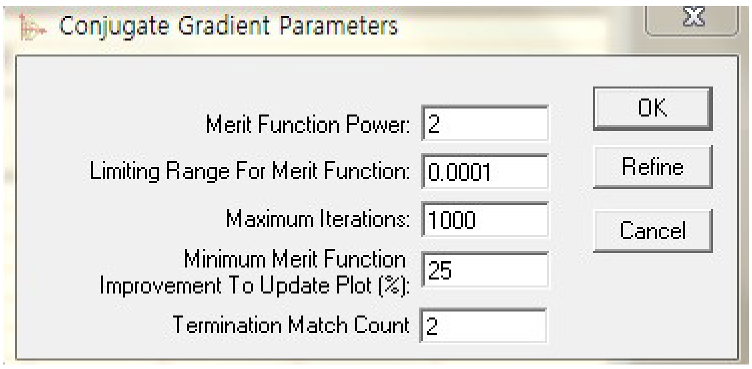
Starting Formula　　Air | L 0.2H 0.2L 1.5H 0.2L 0.2H | Glass

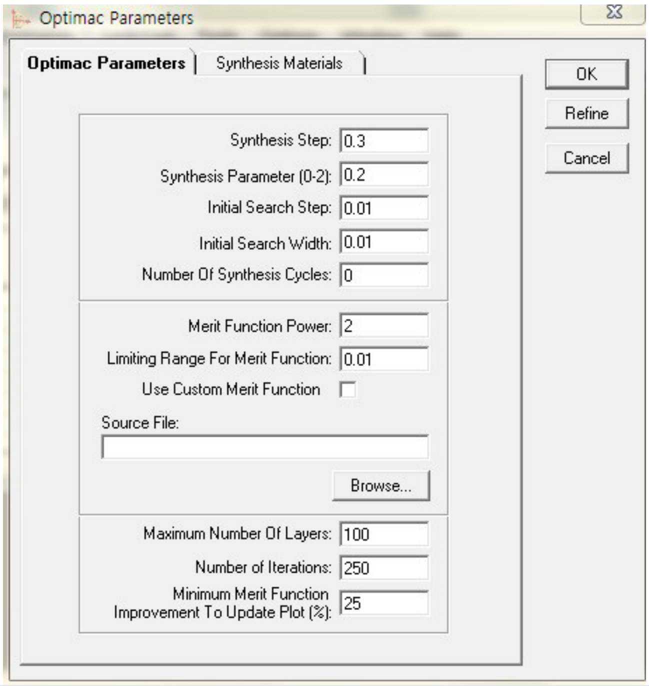
Calculation range　　400nm　　900nm

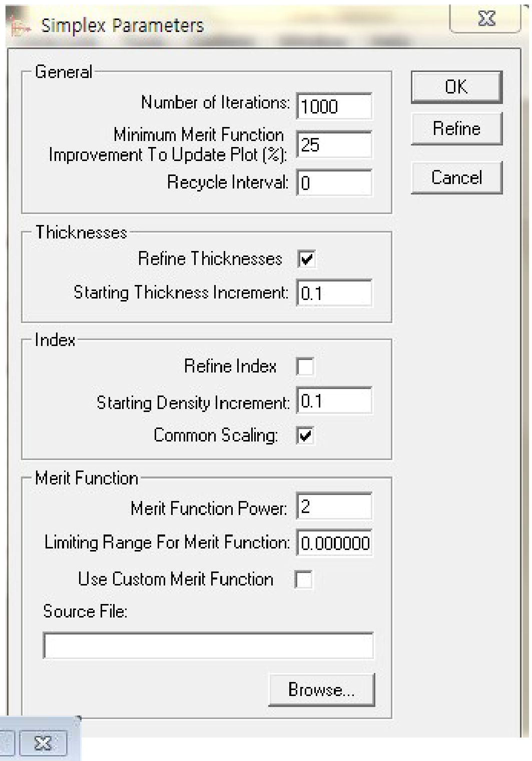


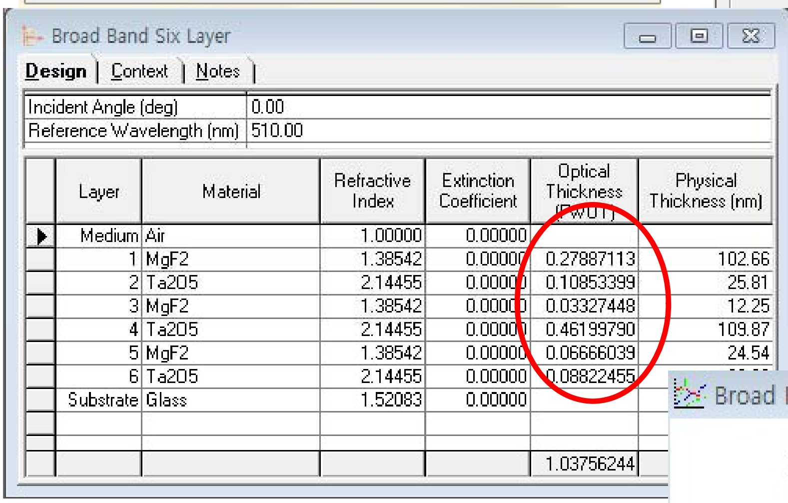
Formula를 수행하고,

Refinement : Simplex, Optimac 또는 Conjugate Gradient의 "Refine" 실행.







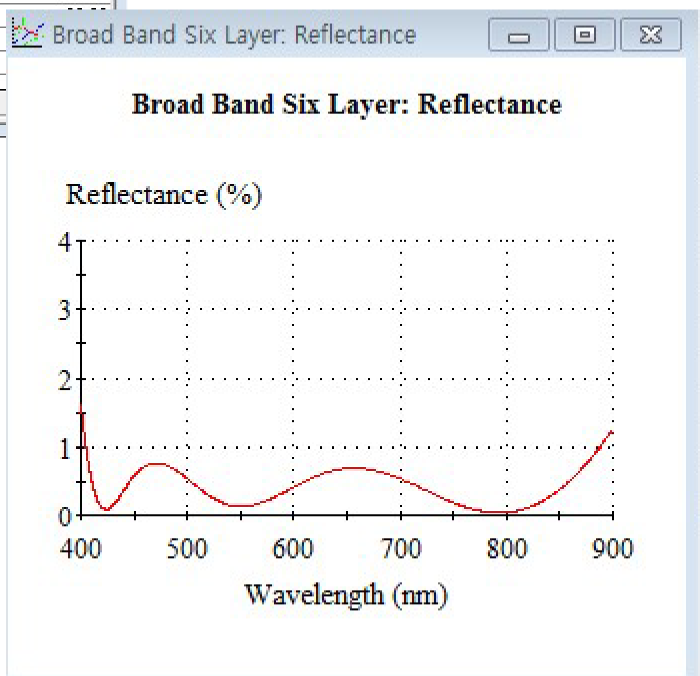


Broad Band Six Layer

Design | Context | Notes

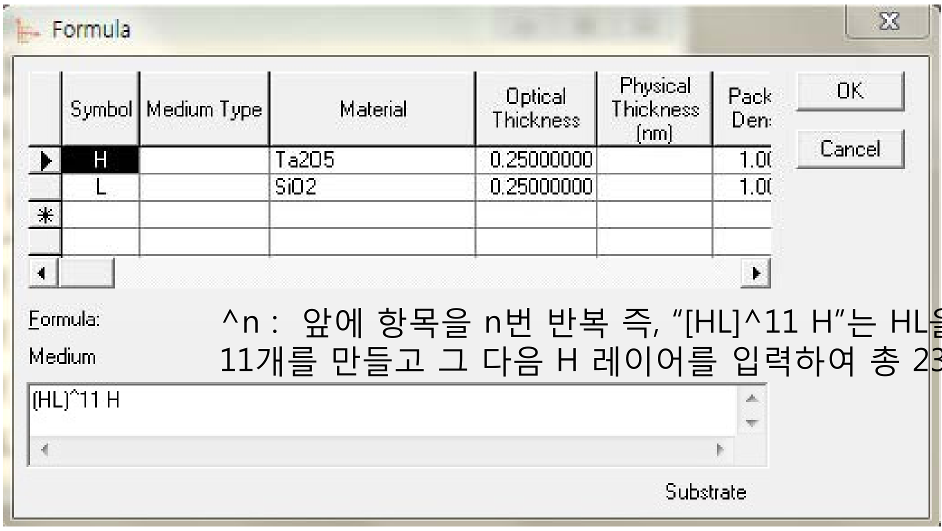
Incident Angle (deg)	0.00
Reference Wavelength (nm)	510.00

Layer	Material	Refractive Index	Extinction Coefficient	Optical Thickness (FWOT)	Physical Thickness (nm)
Medium	Air	1.00000	0.00000		
1	MgF2	1.38542	0.00000	0.27887113	102.66
2	Ta2O5	2.14455	0.00000	0.10853399	25.81
3	MgF2	1.38542	0.00000	0.03327448	12.25
4	Ta2O5	2.14455	0.00000	0.46199790	109.87
5	MgF2	1.38542	0.00000	0.06666039	24.54
6	Ta2O5	2.14455	0.00000	0.08822455	[illegible]
Substrate	Glass	1.52083	0.00000		
				1.03756244	

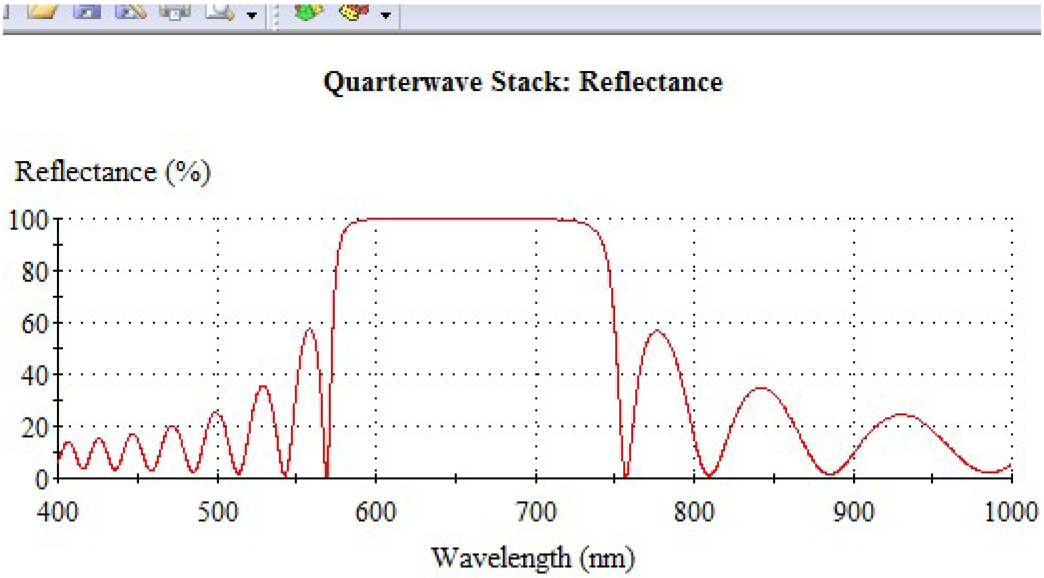


9. Quarterwave Stack

Incident Medium: Air		Substrate: Glass	
λ0: 650nm			
Symbol	Material	Optical Thickness (FWOT)	Physical Thickness (nm)
L	SiO22	0.25	
H	Ta2O5	0.25	
Starting Formula		Air | (HL)^11 H | Glass	
Calculation range		400nm	1000nm



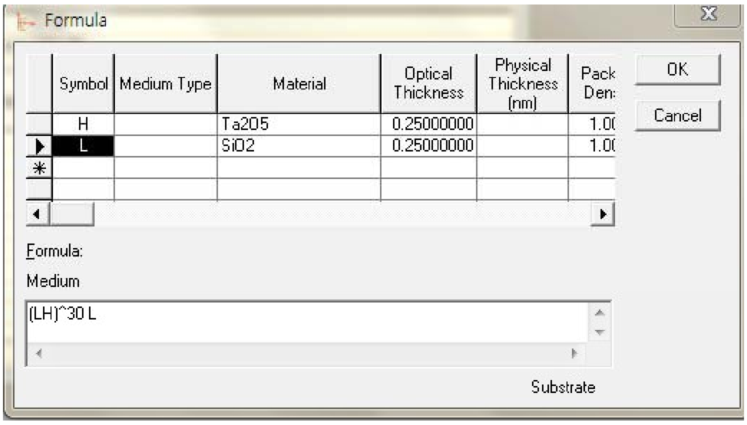
^n : 앞에 항목을 n번 반복 즉, “[HL]^11 H”는 HL을 반복하여 11개를 만들고 그 다음 H 레이어를 입력하여 총 23 layers을 작성.



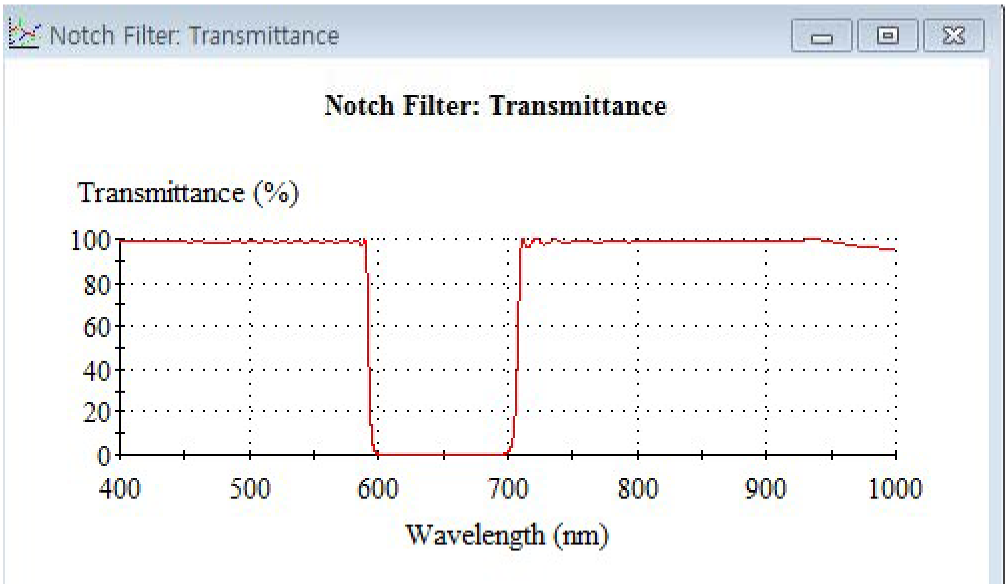
Quarterwaves 는 최대의 간섭 효과를 준다.

10. Notch Filter

Incident Medium: Air		Substrate: Glass	
λ0: 650nm			
Symbol	Material	Optical Thickness (FWOT)	Physical Thickness (nm)
L	SiO2	0.25	
H	Ta2O5	0.25	
Starting Formula		Air | (LH)^30 L | Glass	
Calculation range		400nm 1000nm	



^n : 앞에 항목을 n번 반복
즉, "[HL]^30 H" 은 HL을 반복하여 30개를 만들고 그 다음 H 레이어를 입력하여 총 61 layers을 작성.



active plot을 이용
Low-index layers는 두께를 증가, Low-index layers는 두께를 작게하여 조정한 다음 "Conjugate Gradient" refinement을 최적화.

11. Non Polarizing Beam Splitter

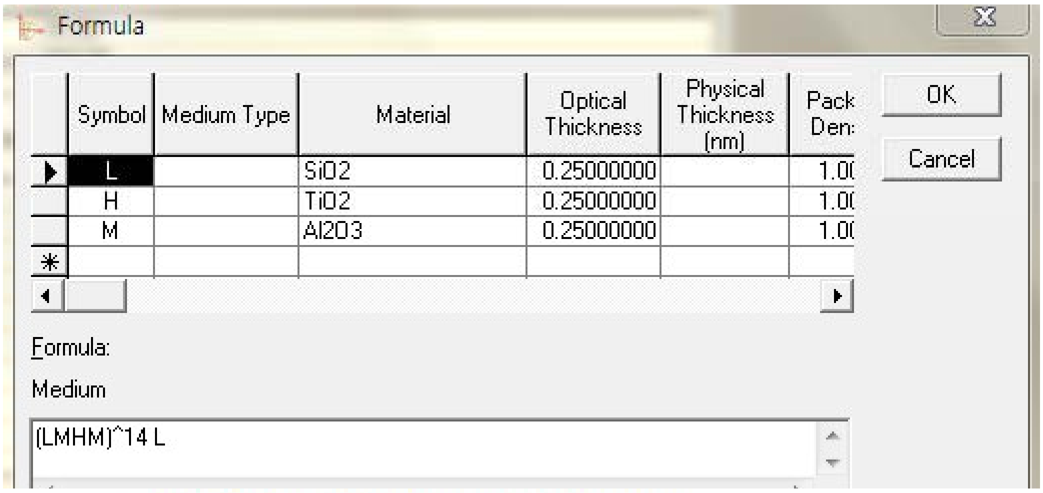
Incident Medium: Air   Substrate: Glass

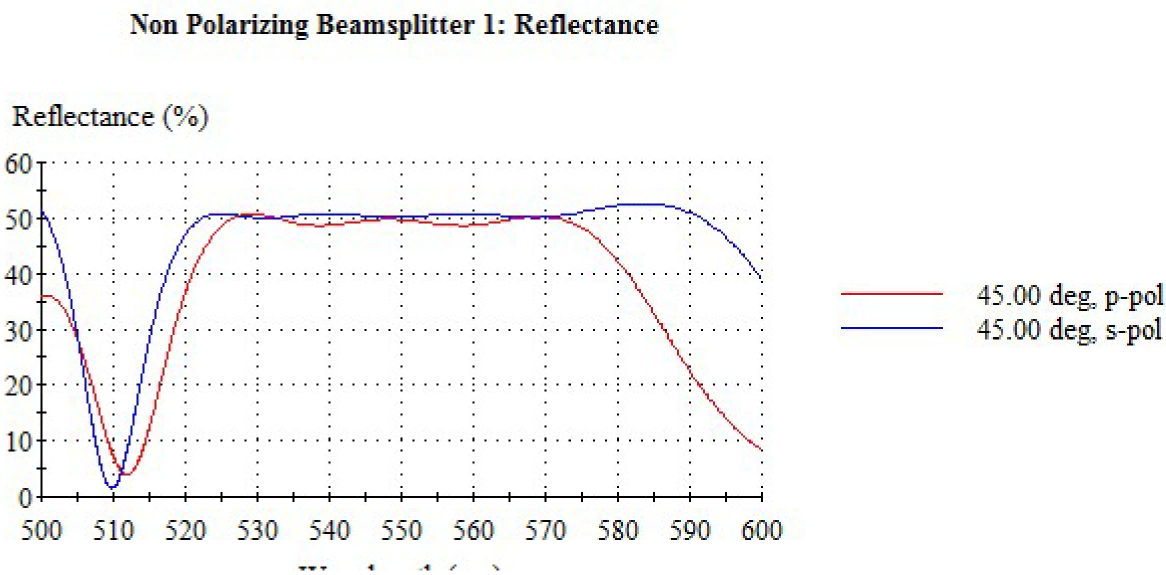
λ0: 550nm   Match Angle: 45°

Symbol	Material	Optical Thickness (FWOT)	Physical Thickness (nm)
L	SiO_2	0.25	
M	Al_2O_3	0.25	
H	TiO_2	0.25	

Starting Formula   Air | (LMHM)^14 L | Glass

Calculation range   400nm   700nm



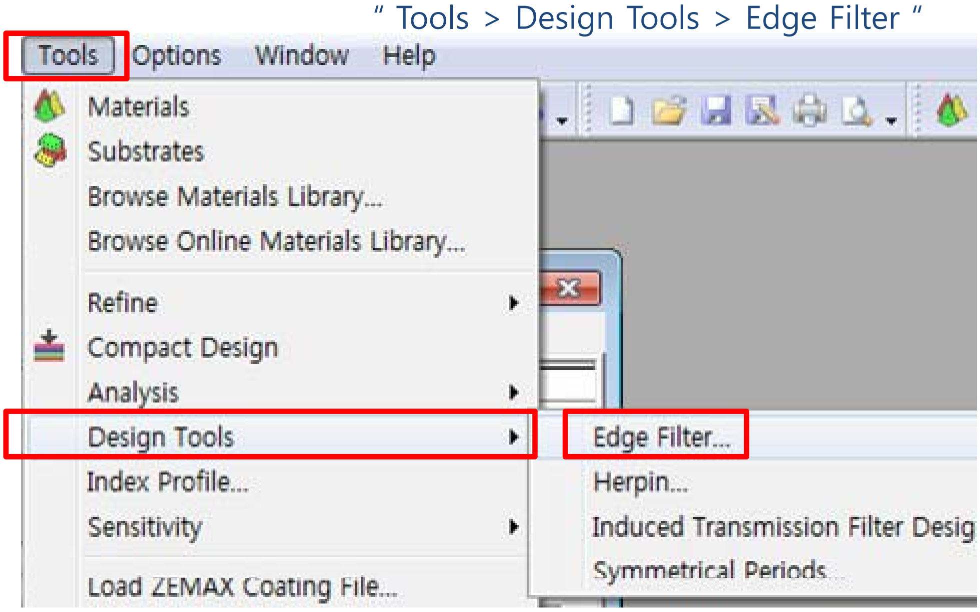


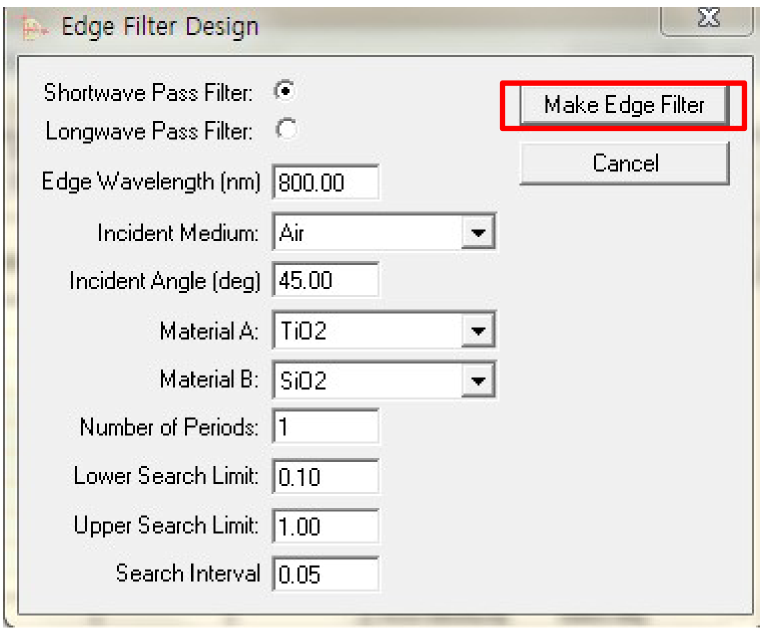
Refinement는 " Simplex 또는 Optimac " 적용.

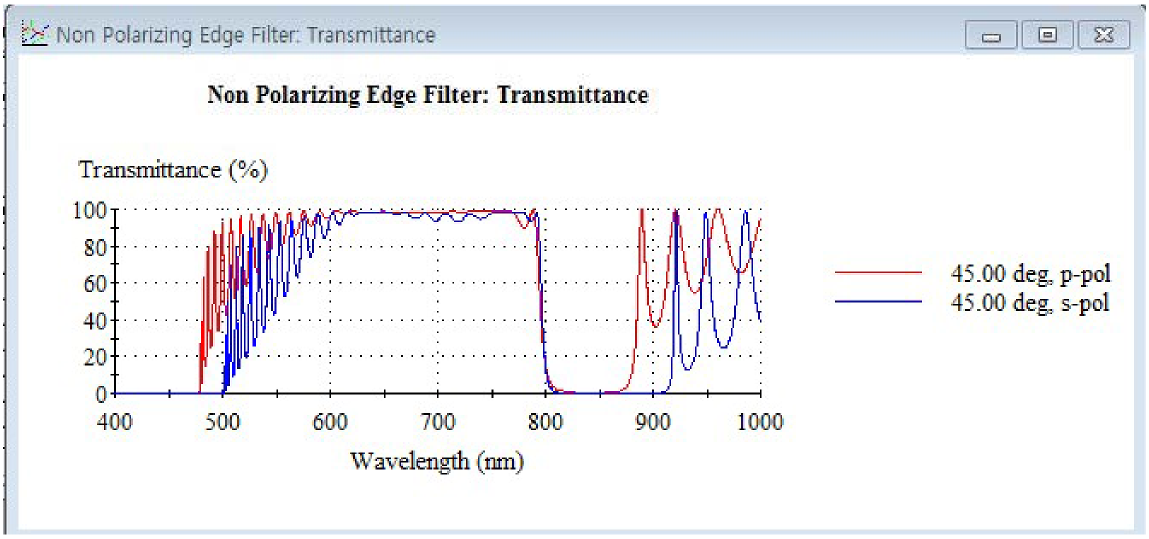
12. Non Polarizing Edge Filter

Incident Medium: Air		Substrate: Glass	
λ0: 800nm	*45° Incidence*		
Symbol	Material	Optical Thickness (FWOT)	Physical Thickness (nm)
L	MgF_2	0.25	
H	TiO_2	0.25	
Starting Formula		None. Use Edge Filter Tool	
Calculation range		400nm	1000nm

" Tools > Design Tools > Edge Filter "







Non Polarizing Edge Filter: Transmittance
Non Polarizing Edge Filter: Transmittance
Transmittance (%)
100
80
60
40
20
0
400
500
600
700
800
900
1000
Wavelength (nm)
45.00 deg, p-pol
45.00 deg, s-pol

13. Layer Longwave Pass Filter

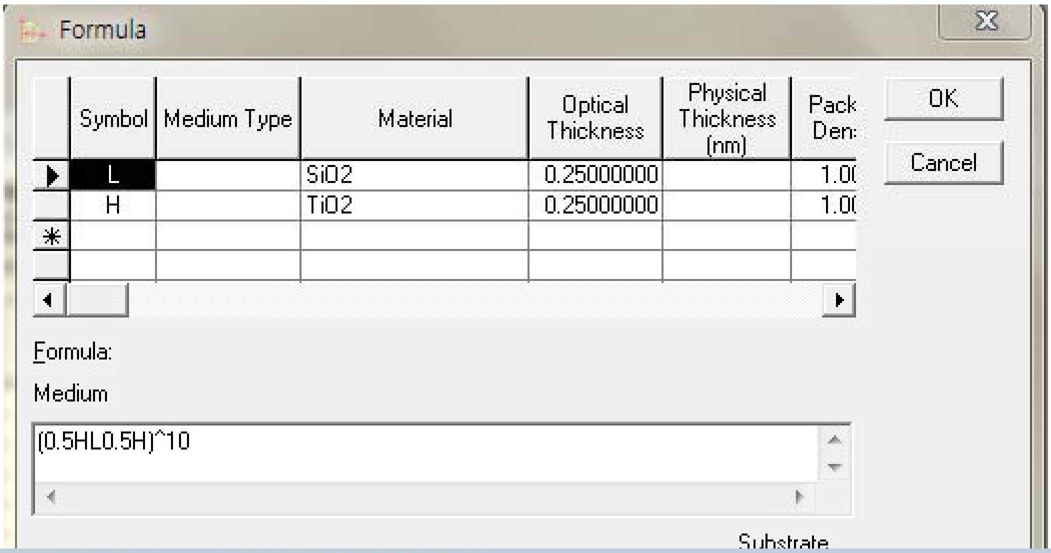
Incident Medium: Air　　Substrate: Glass

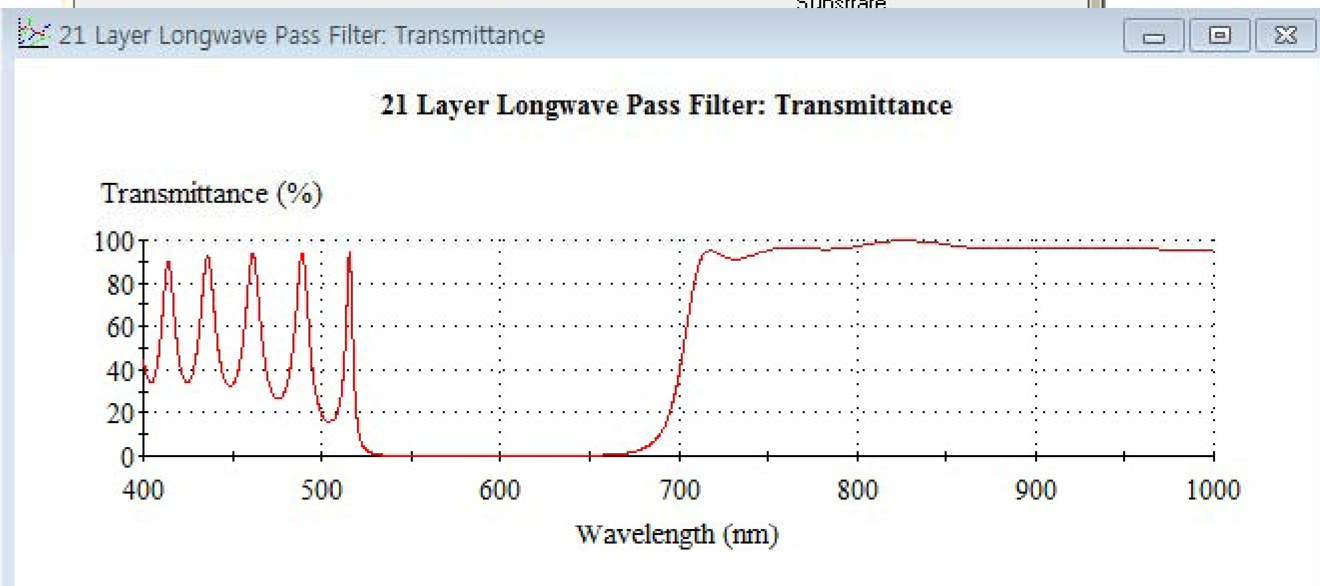
λ0: 600nm

Symbol	Material	Optical Thickness (FWOT)	Physical Thickness (nm)
L	SiO_2	0.25	
H	TiO_2	0.25	

Starting Formula　　Air | (0.5H L 0.5H)^10 | Glass

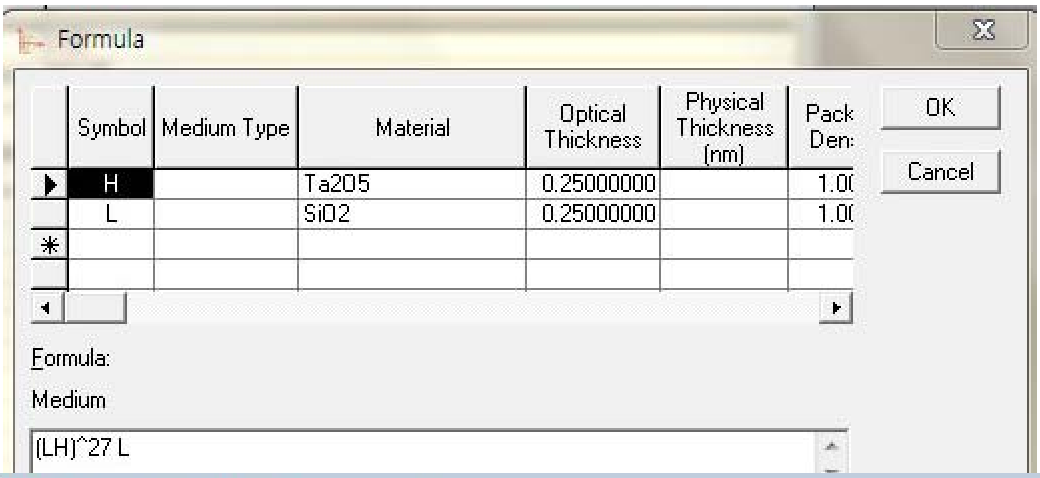
Calculation range　　400nm　　1000nm

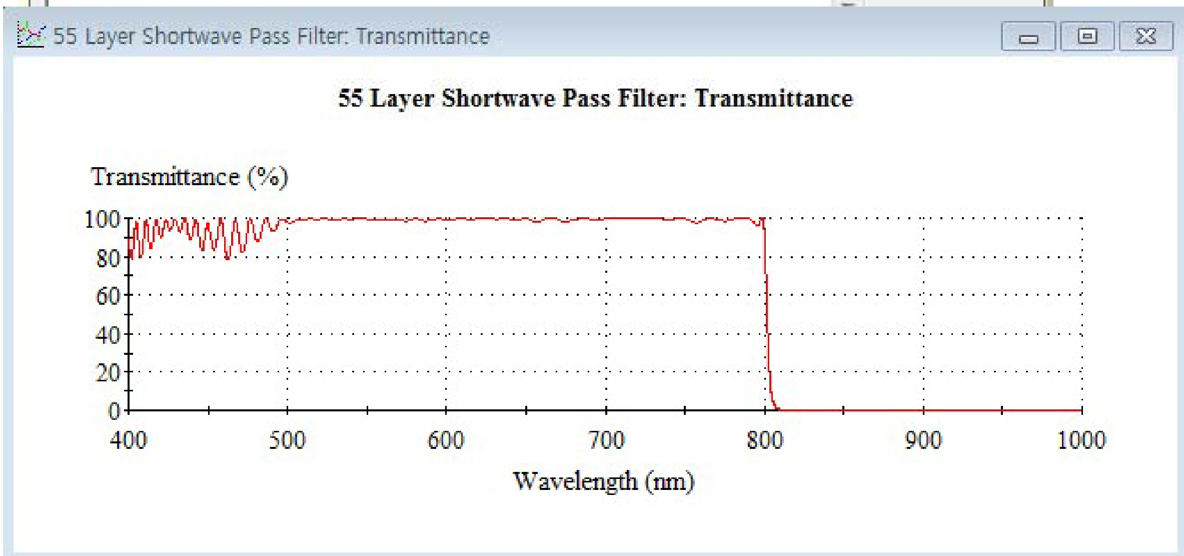




14. 55 Layer Shortwave Pass Filter

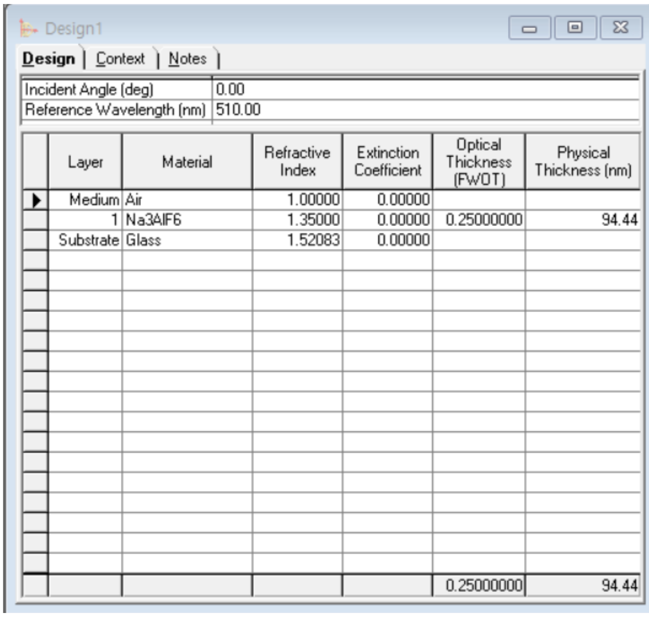
Incident Medium: Air		Substrate: Glass
λ0: 897nm		
Symbol	Material	Optical Thickness (FWOT) Physical Thickness (nm)
L	SiO_2	0.25
H	Ta_2O_5	0.25
Starting Formula		Air | (LH)^27 L | Glass
Calculation range		400nm 1000nm





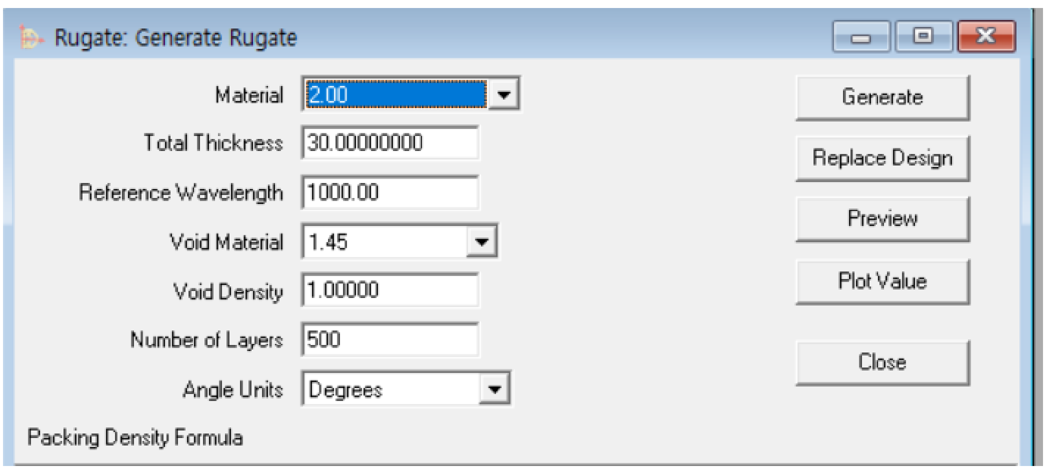
Refinement로 “Optimac” 적용

15. Rugate



Incident Angle (deg)	0.00
Reference Wavelength (nm)	510.00

Layer	Material	Refractive Index	Extinction Coefficient	Optical Thickness (FWOT)	Physical Thickness (nm)
Medium	Air	1.00000	0.00000		
1	Na3AlF6	1.35000	0.00000	0.25000000	94.44
Substrate	Glass	1.52083	0.00000		
				0.25000000	94.44



! Pre-defined Variables
!
! N - Number of Layers
! L - Current Layer Number
! TotalThickness - Total Optical Thickness
! LayerThickness - Optical Thickness of one layer
! Thickness - Cumulative Optical Thickness to center of current layer
! ReferenceWavelength - Reference Wavelength
! PackingDensity - the Packing Density of the current layer
!
!
!--
! IMPORTANT
! NInc and NSub must not be less than NVoid.
! Void Density must be set at 1.00
!--

```
! The rugate is made up of three sections, two matching structures, one at either end and a central single-line rugate
! First we must define certain parameters. The rugate wavelength can be changed if desired.

RugateWavelength=1000;
LongestWavelength=2000;

NInc=1.52;
NSub=1.52;
NMaterial=2.00;
NVoid=1.45;

! Next the index excursion for the sine wave variation of the rugate

NHigh=1.8;
NLow=1.6;

! Now we calculate the necessary thicknesses of the matching assemblies.

MatchThickness=LongestWavelength/(2*ReferenceWavelength);

! The thickness available for the rugate is what is left.

RugateThickness=TotalThickness-2*MatchThickness;

! The three regions must be defined by logical statements. The region will be recognized by a value of unity.
! This means we must have a minus sign in front of the logical statements as shown.
! Remember that Thickness is a predefined variable that corresponds to the thickness at the center of the current layer.

Match1=-(Thickness<=MatchThickness);
Rugate=-(Thickness>MatchThickness&Thickness<TotalThickness-MatchThickness);
Match2=-(Thickness>=TotalThickness-MatchThickness);

! The required parameters are mostly given in this rugate in terms of refractive indices.
! The rugate design will be defined in terms of packing density and so we have to convert.
! We need the terminal packing densities at incident medium and substrate. These
! give terminal indices equal to those of incident medium and substrate respectively.

PFirst=(NInc-NVoid)/(NMaterial-NVoid);
PLast=(NSub-NVoid)/(NMaterial-NVoid);
```

! Next calculate the swing in packing density for the rugate.

PHigh=(NHigh-NVoid)/(NMaterial-NVoid);
PLow=(NLow-NVoid)/(NMaterial-NVoid);
PMean=(PHigh+PLow)/2;
PAmplitude=(PHigh-PLow)/2;

! The argument of the sine function that will generate the rugate is required.
! Note that a complete rugate cycle occupies one half of the rugate wavelength.
! Also the design will be defined at the reference wavelength that may be different from the rugate.
! We want the sine function to start at zero angle and so we have to subtract the thickness of the first
! matching section from the variable Thickness to obtain the parameter we need to insert in the argument.

RugateArgument=360*(Thickness-MatchThickness)*ReferenceWavelength*2/RugateWavelength;

! The packing density variation for the rugate is then a simple sine function.

PRugate=PAmplitude*sin(RugateArgument);

! Additional rugates at different wavelengths can be added if required.
! For example:
PRugate=PAmplitude1*sin(RugateArgument1)+PAmplitude2*sin(RugateArgument2) etc.

! Now we need the apodizing function. The rugate sinusoidal variation will be multiplied by this.
! We use a half cycle of a sine function so that the rugate thickness corresponds to 180 degrees.

Apodization=sin(180*(Thickness-MatchThickness)/RugateThickness);

! Finally we set up the various parts of the entire structure. The rugate part so far is just a sinusoidal variation. It must
! be multiplied by the apodizing function and then must be added to the mean packing density. For the matching structures we find it easier
! to use a single quartercycle of a sine function and to square it to give the shape we need (equivalent to 4th and 1st quadrants).

Match1: PackingDensity=PFirst+(PMean-PFirst)*(sin(90*Thickness/MatchThickness))^2;
Match2: PackingDensity=PLast+(PMean-PLast)*(sin(90*Thickness/MatchThickness))^2;
Rugate: PackingDensity=PMean+Apodization*PRugate;

Rugate from Medium v10 n4

Design | Context | Notes

Incident Angle (deg)	0.00
Reference Wavelength (nm)	1000.00

Layer	Packing Density	Material	Refractive Index	Extinction Coefficient	Optical Thickness (FWOT)	Physical Thickness (nm)	Void Material
Medium		1.52	1.52000	0.00000			
1	0.12800	2.00	1.52040	0.00000	0.06000000	39.46	1.45
2	0.13377	2.00	1.52357	0.00000	0.06000000	39.38	1.45
3	0.14511	2.00	1.52981	0.00000	0.06000000	39.22	1.45
4	0.16161	2.00	1.53889	0.00000	0.06000000	38.99	1.45
5	0.18269	2.00	1.55048	0.00000	0.06000000	38.70	1.45
6	0.20761	2.00	1.56419	0.00000	0.06000000	38.36	1.45
7	0.23548	2.00	1.57951	0.00000	0.06000000	37.99	1.45
8	0.26531	2.00	1.59592	0.00000	0.06000000	37.60	1.45
9	0.29605	2.00	1.61283	0.00000	0.06000000	37.20	1.45
10	0.32661	2.00	1.62963	0.00000	0.06000000	36.82	1.45
11	0.35590	2.00	1.64574	0.00000	0.06000000	36.46	1.45
12	0.38289	2.00	1.66059	0.00000	0.06000000	36.13	1.45
13	0.40662	2.00	1.67364	0.00000	0.06000000	35.85	1.45
14	0.42625	2.00	1.68444	0.00000	0.06000000	35.62	1.45
15	0.44109	2.00	1.69260	0.00000	0.06000000	35.45	1.45
16	0.45060	2.00	1.69783	0.00000	0.06000000	35.34	1.45
17	0.45446	2.00	1.69996	0.00000	0.06000000	35.30	1.45
18	0.45514	2.00	1.70033	0.00000	0.06000000	35.29	1.45
					30.00000000	17729.04	

2.00

Refractive Index Model: Table
Extinction Coefficient Model:
Internal Transmittance Model: Undefined

n & k | Properties | Notes

Wavelength (nm)	Refractive Index	Extinction Coefficient
100.00	2.00000	0.00000
10000.00	2.00000	0.00000

1.52

Refractive Index Model: Table
Extinction Coefficient Model:
Internal Transmittance Model: Undefined

n & k | Properties | Notes

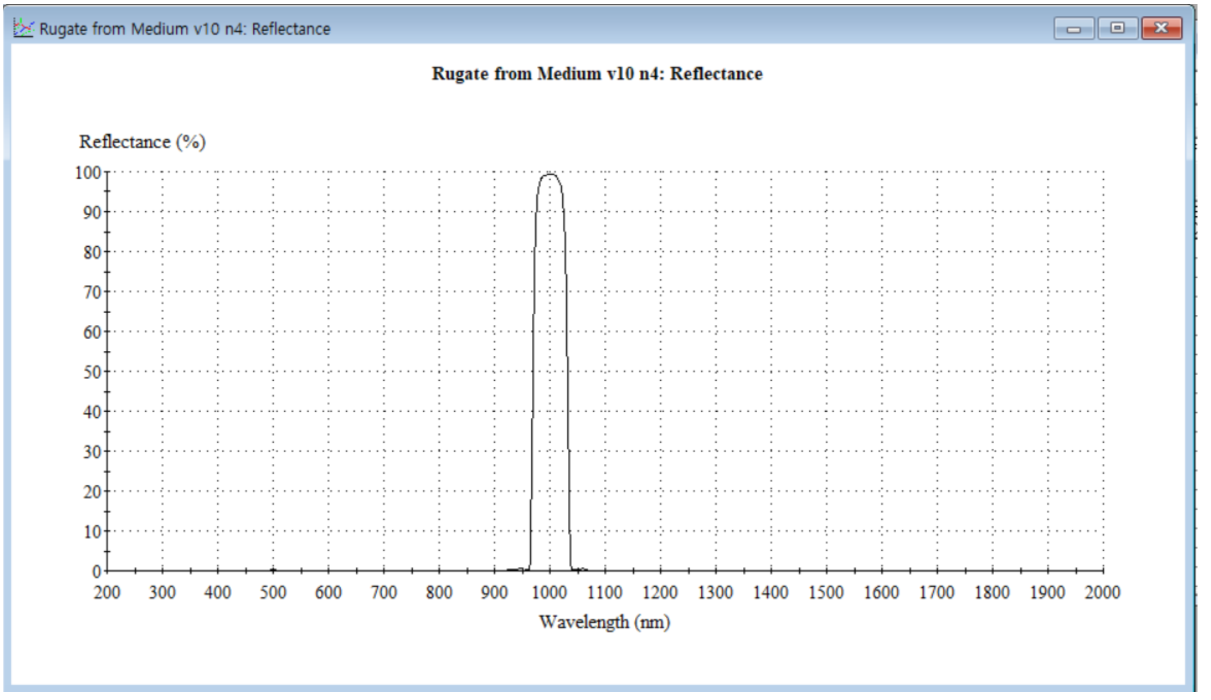
Wavelength (nm)	Refractive Index	Extinction Coefficient
100.00	1.52000	0.00000
10000.00	1.52000	0.00000

1.45

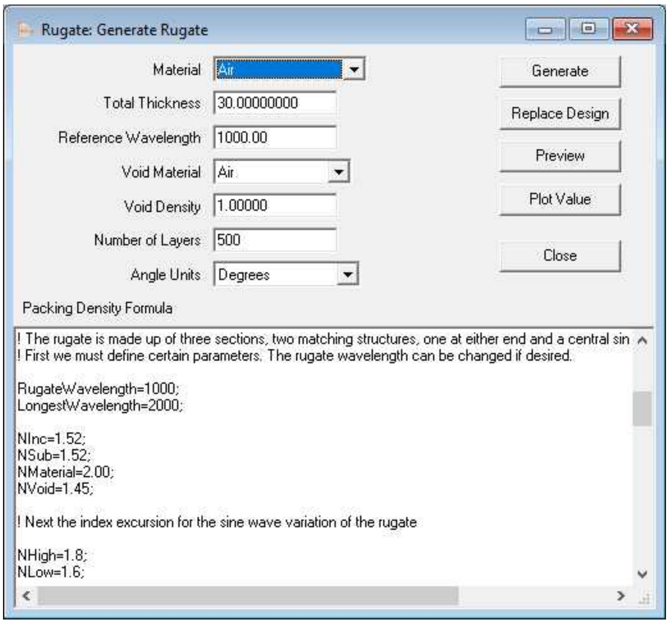
Refractive Index Model: Table
Extinction Coefficient Model:
Internal Transmittance Model: Undefined

n & k | Properties | Notes

Wavelength (nm)	Refractive Index	Extinction Coefficient
100.00	1.45000	0.00000
10000.00	1.45000	0.00000



다음 페이지는 영문 매뉴얼 내용 입니다.



The limits of the index variation may easily be established by setting the **Material** parameter to a material that represents the highest refractive index that is present in the coating, setting the **Void Material** to a material that represents the lowest refractive index that is present in the coating and setting the **Void Density** to 1. As the packing density varies from 1 to 0, the refractive index will vary from the **Material** refractive index to the **Void Material** refractive index. Since the layer refractive indices are calculated using the packing density function, other relationships between packing density and refractive index can also be used (for example the valid packing density range may be 0 to 2 instead of 0 to 1).

The total thickness of the rugate structure is specified in optical by the **Total Thickness** value. The **Reference Wavelength** must also be specified. **Number of Layers** specifies the number of layers that are used to model the rugate structure. Increasing the number of layers improves the accuracy of the calculations at the expense of increased calculation time. A good starting point is to set the number of layers so that each layer is about one eighth of a wave thick at the shortest operating wavelength of the structure. To check the quality of the performance calculations, increase (or reduce) the number of layers and calculate the performance again. If there is little or no change in performance, then the number of layers is sufficient.

The Packing Density Formula is used to enter a set of statements that specify how the packing density varies through the set of layers. The formula consists of one or more statements. Each statement consists of an optional *Condition*, and an *Assignment*. A *Condition* is specified by an *Expression* followed by a colon (":") An *Assignment* is a *Variable* name followed by an equal sign ("=") followed by an *Expression* and ends with a semi-colon (";"). Any text after an exclamation point ("!") is ignored up to the end of the line.

When a rugate structure is being generated, the statements in the Packing Density Formula are executed in order from top to bottom. If a statement has a *Condition*, then the *Assignment* is only executed if the value of the *Expression* in the *Condition* is not zero. If the statement does not have a *Condition*, then the *Assignment* is always executed. The *Assignment* calculates the value of the *Expression* and stores the value in the *Assignment Variable*. *Variables* are automatically created if they do not already exist. There are several special variables:

L	The current layer number. This variable cannot be modified. The first layer is numbered 1 and the last layer has the value **N**.
N	The number of layers as entered in the Number of Layers box. This variable cannot be modified.
TotalThickness	Total Thickness as entered in the Total Thickness box. This variable cannot be modified.
LayerThickness	The Thickness of one layer: (**TotalThickness** / **N**). This variable cannot be modified.
Thickness	Cumulative Thickness to center of current layer: (**L**-1) * **LayerThickness** + **LayerThickness** / 2. This variable cannot be modified.
ReferenceWavelength	Reference Wavelength as entered in the Reference Wavelength box. This variable cannot be modified.
PackingDensity	The Packing Density of the current layer. After all the statements have been executed, the current layer's packing density will be the value of this variable. This variable can be modified.

The following operators are supported in *Expressions*:

()	sub-expressions
^	power
*, /	multiplication, division
%	modulus (remainder)
\	integer divide
+, -	addition, subtraction
>, >=, <, <=, <>	logical comparison
&, |	logical "and", logical "or"

An operator that is listed on a line above another operator has a higher precedence. The following functions are also supported (they are not case sensitive): Abs, Sin, Cos, Tan, ACos, ASin, Atn, Log, Log10, Exp, Sqr, Int, Frac, Ceil, and Floor. Trigonometric functions accept and return angles expressed in radians or degrees, depending on the setting of **Angle Units**.

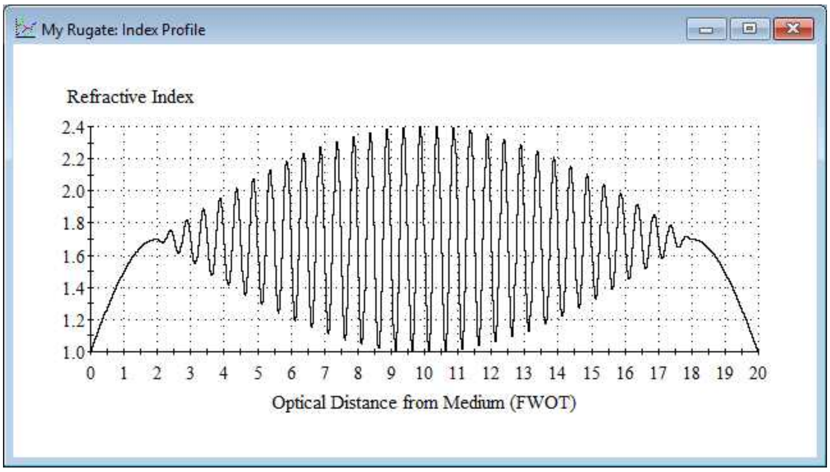
For example, the formula:

PackingDensity = (1 + sin(360 * L/N))/2;

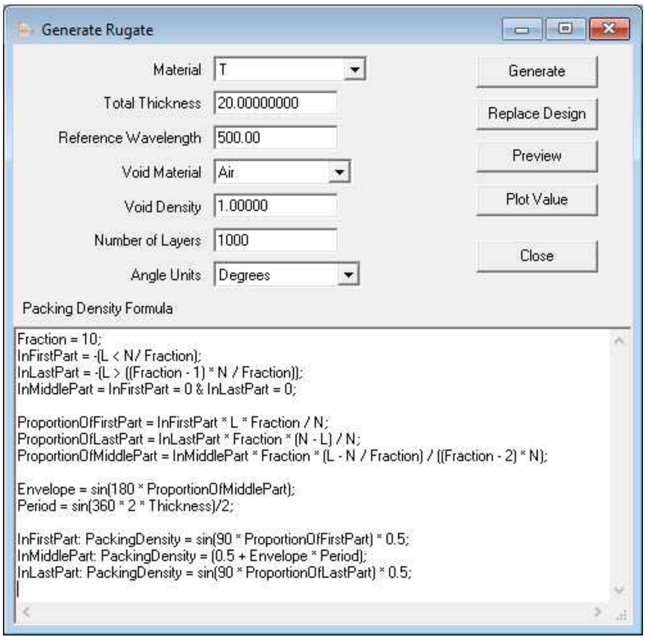
generates a rugate structure consisting of a single period of a sine wave.

Click **Preview** to generate an index profile plot of the rugate structure. This allows you to verify that the correct structure has been generated. The rugate structure can be made available to the design in two ways: Clicking **Generate** will put the layers of the rugate structure onto the clipboard. These layers can be pasted into any design in the normal way. Clicking **Replace Design** will cause the current design's layers to be completely replaced with the layers of the rugate structure. Selecting a variable name in the Packing Density Formula and then clicking **Plot Value** will display a plot showing the value of the variable as a function of thickness. This is useful for making sure that the variable's value is set correctly during rugate generation.

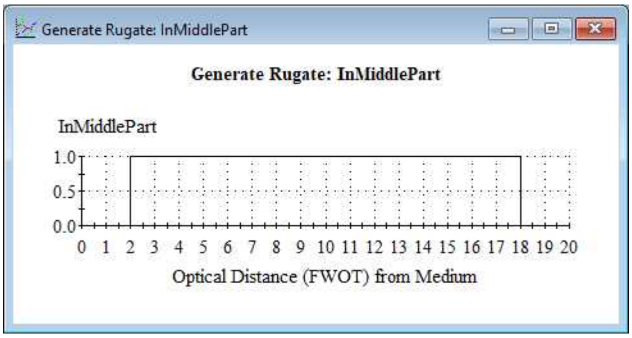
Here is a more complicated example. In this example, we want to generate the following refractive index profile:



There are three parts to this rugate. The first part is the rise in refractive index from 1.0 to 1.7. This is achieved by the first 90 degrees of a sine wave profile. The second part is a sine wave profile of 32 cycles modulated by a half sine wave profile. The last part is a fall in refractive index from 1.7 to 1. This is achieved by the following Generate Rugate form:



The first four lines set up the three parts of the rugate. The first and last parts are each one tenth of the total thickness and the second part is eight tenths of the total thickness. **InFirstPart** is 1 during the first tenth and 0 elsewhere. **InLastPart** is 1 during the last tenth and 0 elsewhere. **InMiddlePart** is 1 when both **InFirstPart** and **InLastPart** are 0 and 1 elsewhere. Selecting **InMiddlePart** and then clicking **Plot Value** gives the following plot:



ProportionOfFirstPart, **ProportionOfMiddlePart** and **ProportionOfLastPart** start at 0 and linearly increase to 1 in each appropriate part.

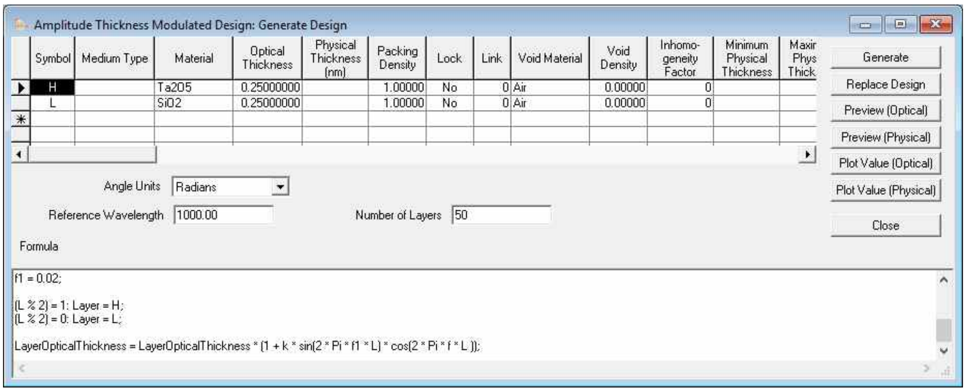
The envelope for the middle part is generated by a sine function that uses **ProportionOfMiddlePart** to generate an angle that varies from 0 to 180 degrees.

The periodic component is generated by another sine function whose period is one half an optical thickness. The periodic component is scaled so that it varies from –0.5 to +0.5 – a total range of 1.

The last three statements generate the packing density variation. These statements use the *Condition* component to control which statement provides the packing density as a function of thickness. For the first part, the first 90 degrees of the sine function are used to raise the packing density from 0 to 0.5 (the midpoint of the packing density range used here). In the middle part, the periodic component is multiplied by the envelope and the result is then shifted up by 0.5 to give a packing density that varies from 0 to 1. The last part is generated by a sine function starting at 90 degrees and reducing to 0.

Generating Complex Designs

In the Essential Macleod, the Formula tool is used to generate designs with regular features. Some designs have more complex features that cannot be expressed by using Formula, such as chirped reflectors. For these designs, the Generate Design tool can be used to generate the layers in the design.



A Generate Design definition consists of default layer parameters represented by single letter symbols, the number of layers in the design and a Formula that specifies the parameters of each layer as a function of layer number.

The Formula is used to enter a set of statements that specify how the layer parameters vary through the set of layers. The formula consists of one or more statements. Each statement consists of an optional *Condition*, and an *Assignment*. A *Condition* is specified by an *Expression* followed by a colon (":") An *Assignment* is a *Variable* name followed by an equal sign ("=") followed by an *Expression* and ends with a semi-colon (";"). Any text after an exclamation point ("!") is ignored up to the end of the line.

When a design is being generated, the statements in the Formula are executed in order from top to bottom. If a statement has a *Condition*, then the *Assignment* is only executed if the value of the *Expression* in the *Condition* is not zero. If the statement does not have a *Condition*, then the *Assignment* is always executed. The *Assignment* calculates the value of the *Expression* and stores the value in the *Assignment Variable*. *Variables* are automatically created if they do not already exist. There are several special variables: