

Composite Films Modeling

Atomistic modelling allows for simulation of various composites based on the materials we have characterized. An effective media approximation is used, which assumes structural dimension (grain size, layer thickness, etc.) is less than 0.1 of minimum wavelength considered. For materials with similar optical properties, ratios determine the properties of the composite. For the materials that differ widely, structure may impact actual performance. Materials marked with r are sputtered using a reactive process, marked n are sputtered from a stoichiometric target.

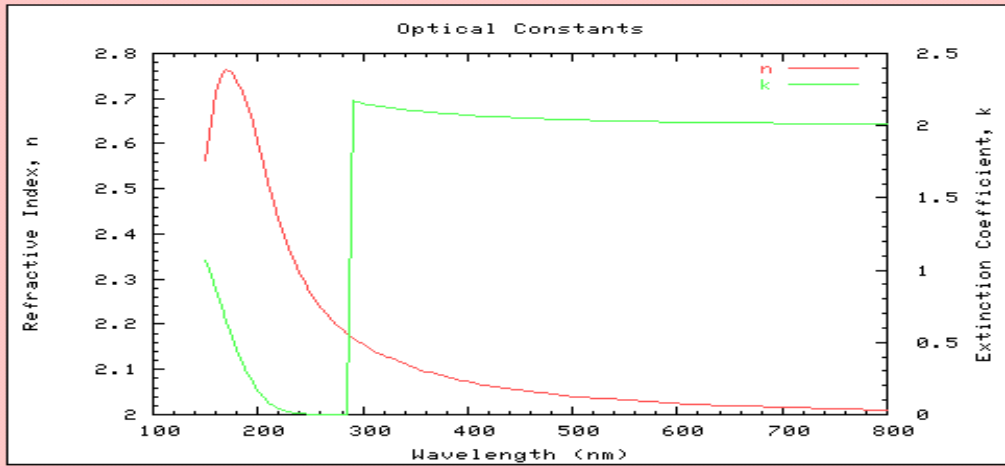
Fill out the form below to create a composite film.

Material 1 (Host):	<input type="text" value="Si3N4"/>	% Material 1:	<input type="text" value="70"/>
Material 2:	<input type="text" value="Ti"/>	% Material 2:	<input type="text" value="30"/>
Material 3:	<input type="text" value="Void"/>	% Material 3:	<input type="text" value="0"/>
Depolarization factor q:	<input type="text" value="0.33"/>		
Substrate:	<input type="text" value="SiO2"/>	Media:	<input type="text" value="Air"/>
Wavelength of interest:	<input type="text" value="193 nm"/>		
Application:	<input type="text" value="APSM"/>		
Thickness (for Thin Film application only):	<input type="text" value="100"/>		nm
<input type="button" value="Calculate"/> <input type="button" value="重設"/>			

圖 4-1 B. W. Smith 教授網站對嵌附層材料之線上計算

APSM MATERIAL MODEL

Film Composition: 100% Si3N4 / 0%al2o3_reactive_vuv / 0%Void



"n&k Plot"
"Transmittance"

Pi phase shift thickness at 193 nm: 586 Å

Composite film optical constants at 193 nm: $n=2.6630$, $k=0.2451$

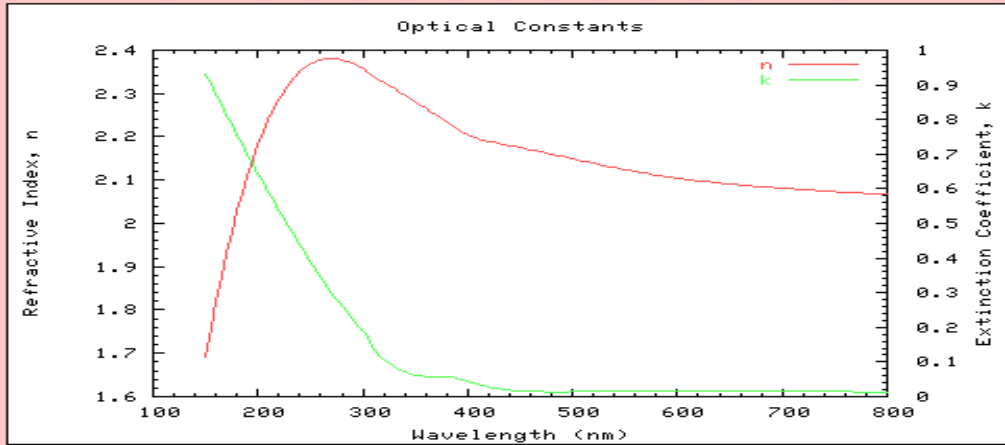
Composite film transmittance at 193 nm: 28.81%

Composite film reflectance at 193 nm: 27.05%



APSM MATERIAL MODEL

Film Composition: 100% si3n4_3_vuv / 0%al2o3_reactive_vuv / 0%Void



"n&k Plot"
"Transmittance"

Pi phase shift thickness at 248 nm: 924 Å

Composite film optical constants at 248 nm: $n=2.3648$, $k=0.3994$

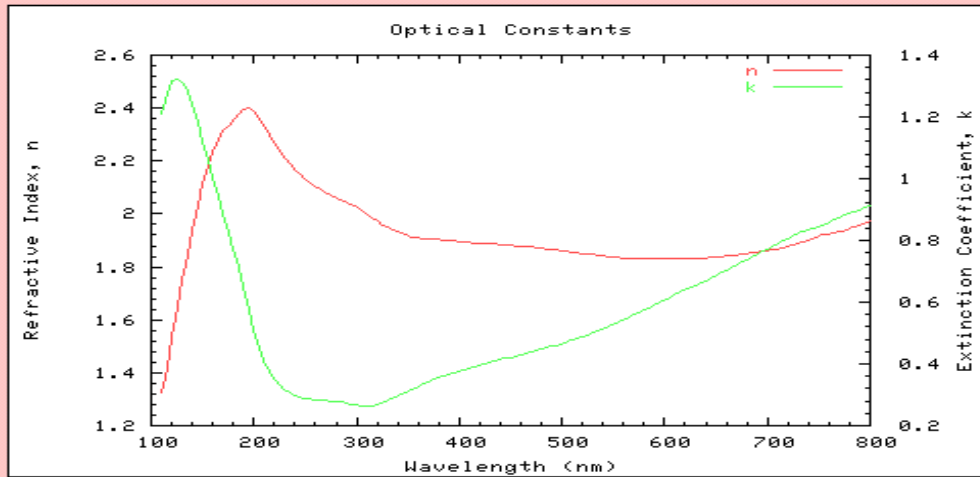
Composite film transmittance at 248 nm: 11.95%

Composite film reflectance at 248 nm: 17.29%

圖 4-2 193 nm 與 248 nm 嵌附層材料 Si₃N₄ 之光學性質計算結果

APSM MATERIAL MODEL

Film Composition: 25% Ti / 75%Si3N4 / 0%Void



"n&k Plot"
"Transmittance"

Pi phase shift thickness at 193 nm: 707 Å

Composite film optical constants at 193 nm: $n=2.3998$, $k=0.6036$

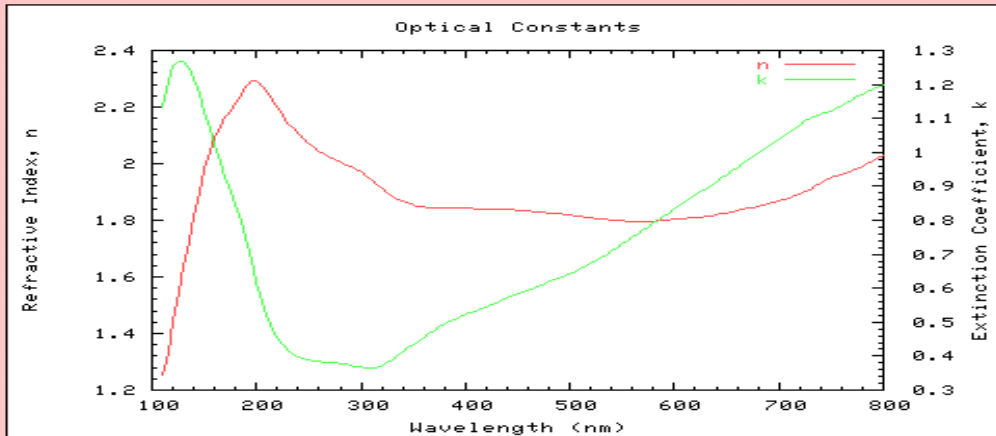
Composite film transmittance at 193 nm: 4.67%

Composite film reflectance at 193 nm: 19.29%



APSM MATERIAL MODEL

Film Composition: 33% Ti / 67%Si3N4 / 0%Void



"n&k Plot"
"Transmittance"

Pi phase shift thickness at 248 nm: 1166 Å

Composite film optical constants at 248 nm: $n=2.0799$, $k=0.3908$

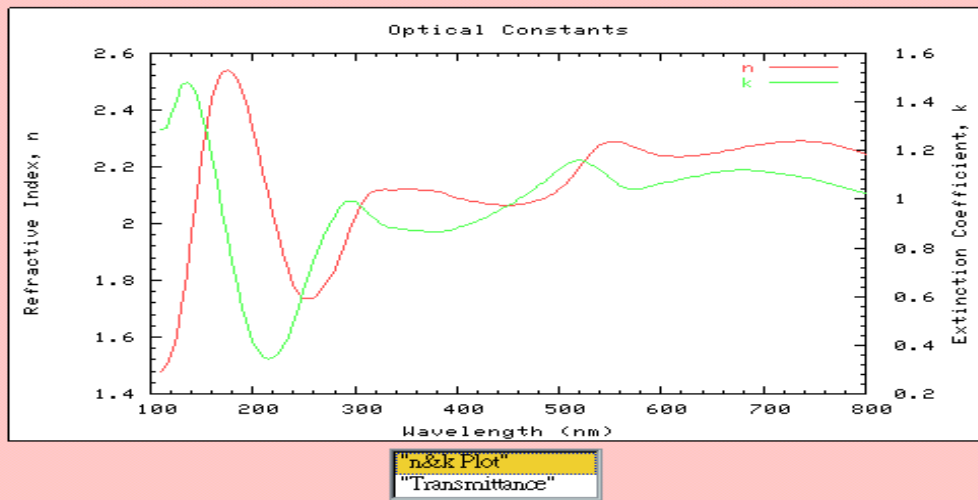
Composite film transmittance at 248 nm: 8.26%

Composite film reflectance at 248 nm: 12.47%

圖 4-3 193 nm 與 248 nm 嵌附層材料 TiSiN 之光學性質計算結果

APSM MATERIAL MODEL

Film Composition: 25% Mo / 75%Si3N4 / 0%Void



Pi phase shift thickness at 193 nm: 690 Å

Composite film optical constants at 193 nm: $n=2.4284$, $k=0.5048$

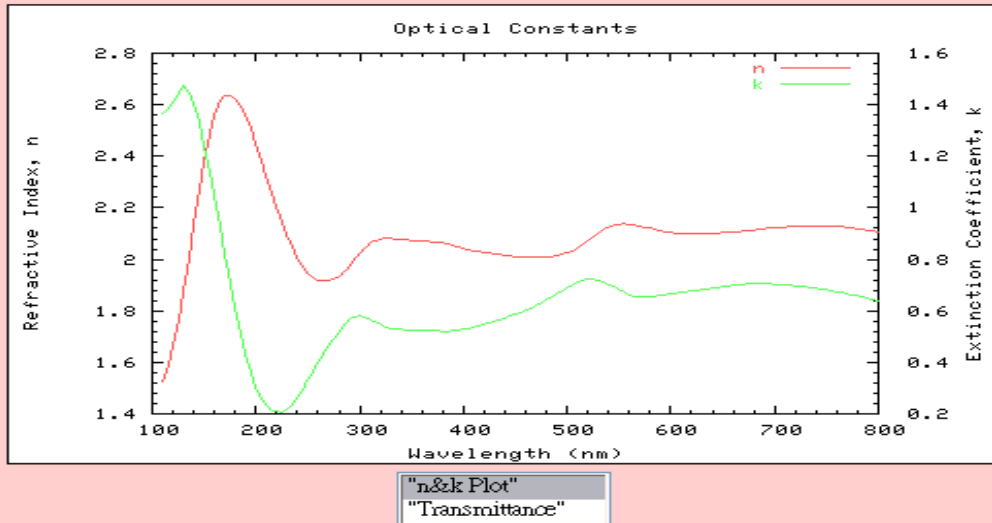
Composite film transmittance at 193 nm: 7.86%

Composite film reflectance at 193 nm: 19.11%



APSM MATERIAL MODEL

Film Composition: 15% Mo / 85%Si3N4 / 0%Void



Pi phase shift thickness at 248 nm: 1312 Å

Composite film optical constants at 248 nm: $n=1.9565$, $k=0.3139$

Composite film transmittance at 248 nm: 10.72%

Composite film reflectance at 248 nm: 10.59%

圖 4-4 193 nm 與 248 nm 嵌附層材料 MoSiN 之光學性質計算結果

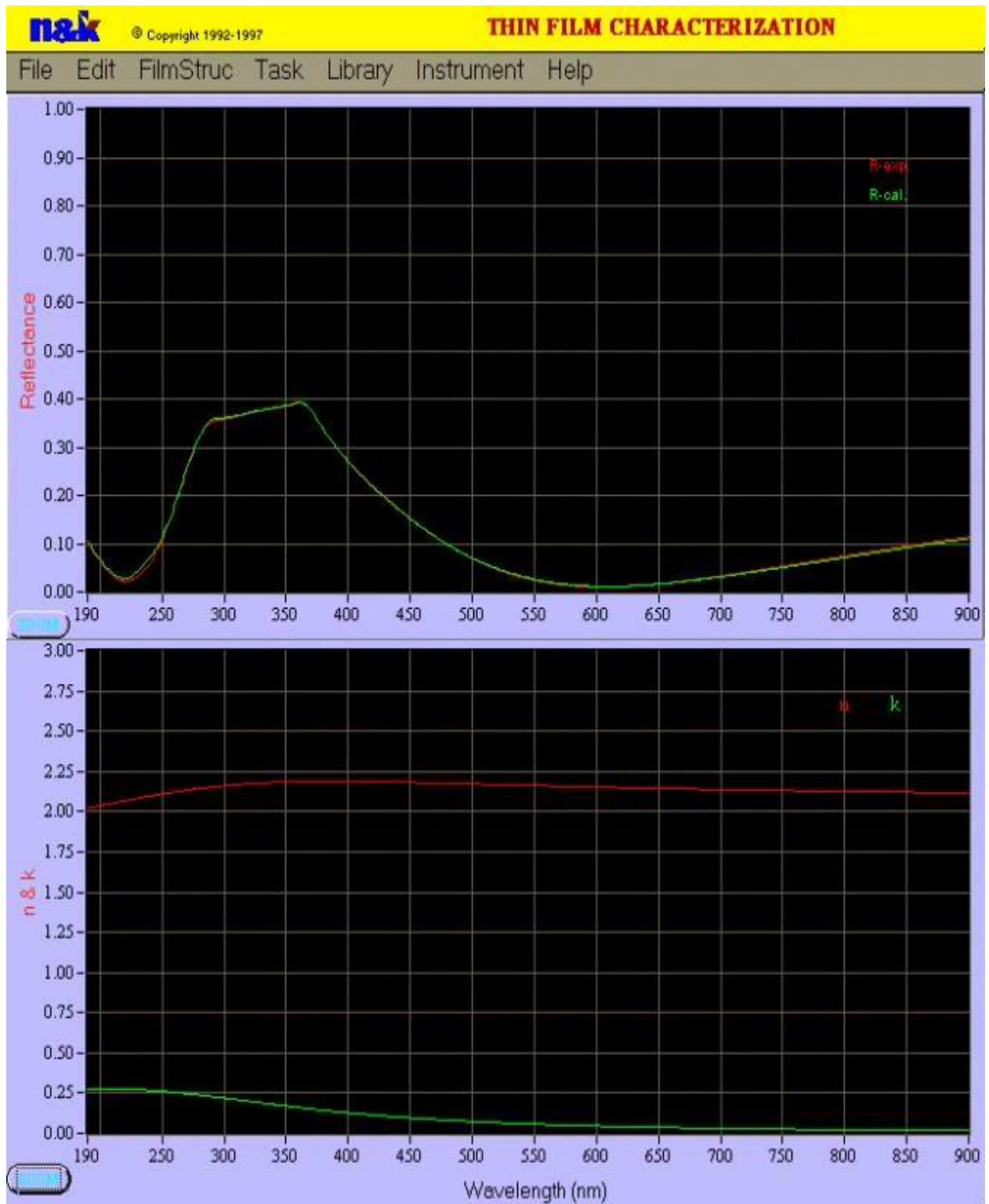


圖 4-5 n&k Analyzer 反射率光譜之曲線附合圖

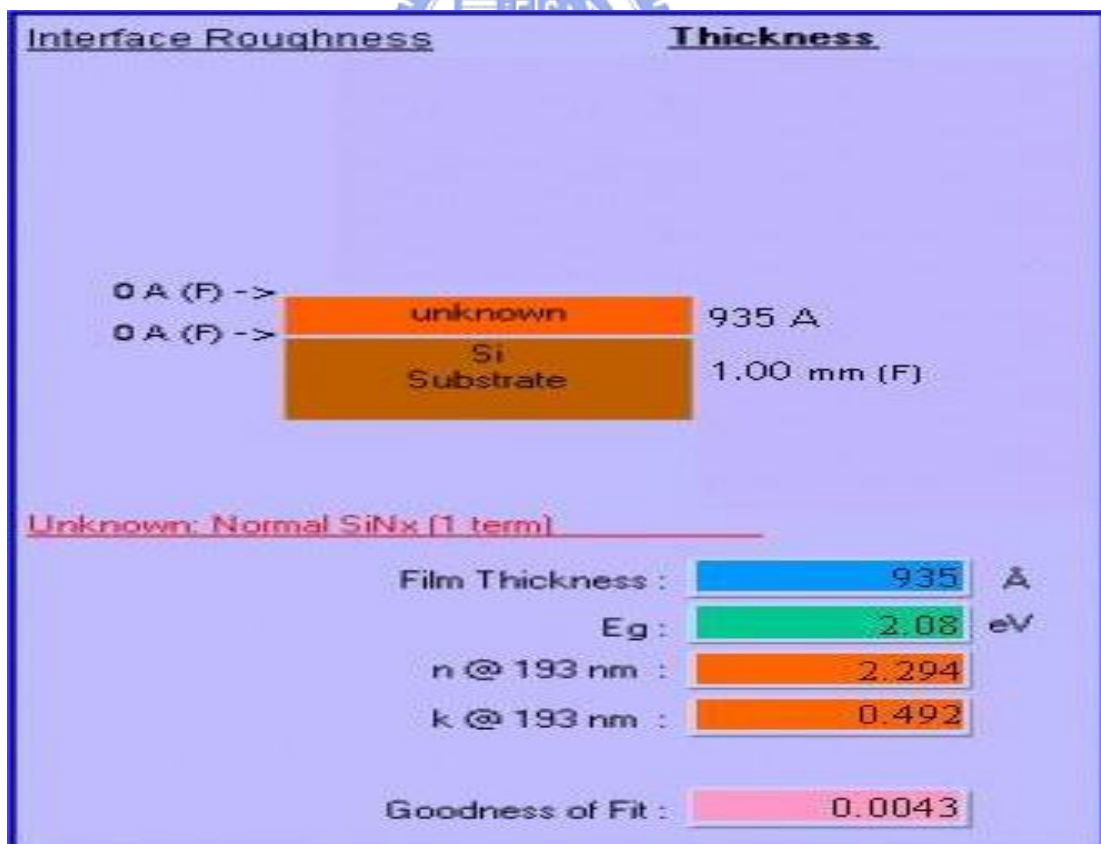
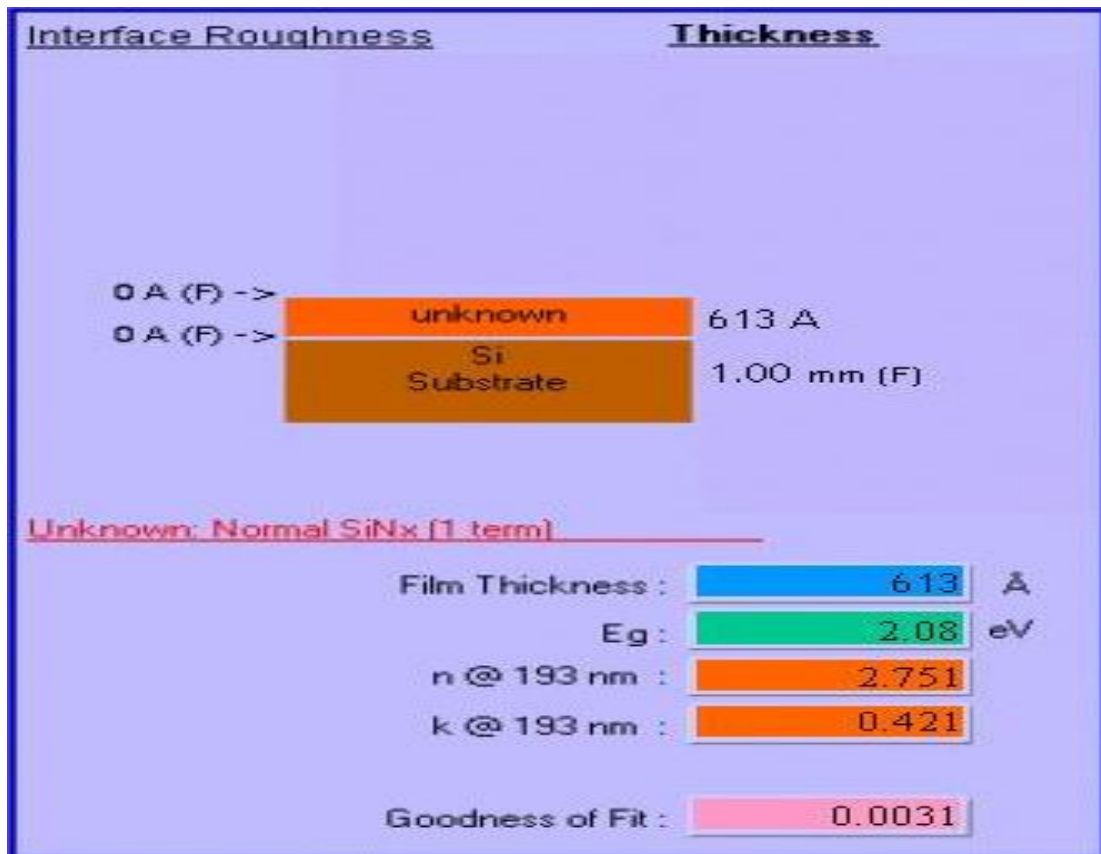


圖 4-6 193 nm 與 248 nm 嵌附層 Si_3N_4 之 n&k Analyzer 量測結果

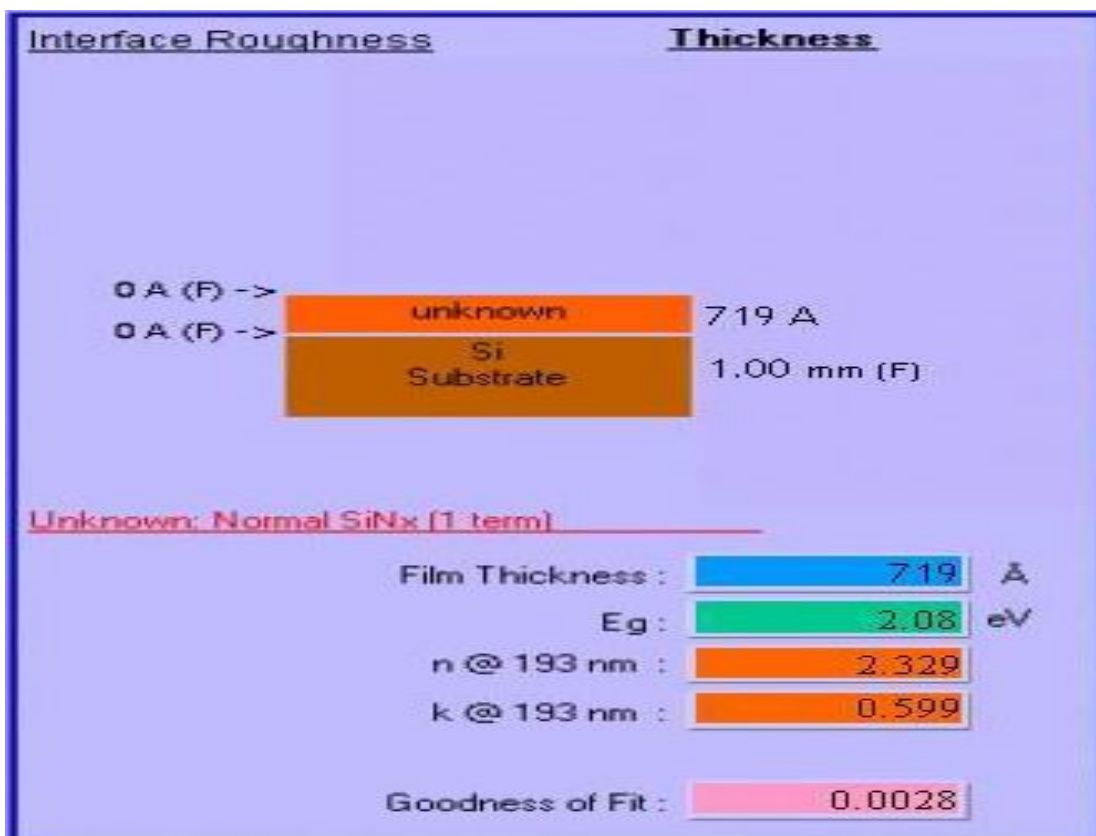


圖 4-7 193 nm 與 248 nm 嵌附層 TiSiN 之 n&k Analyzer 量測結果

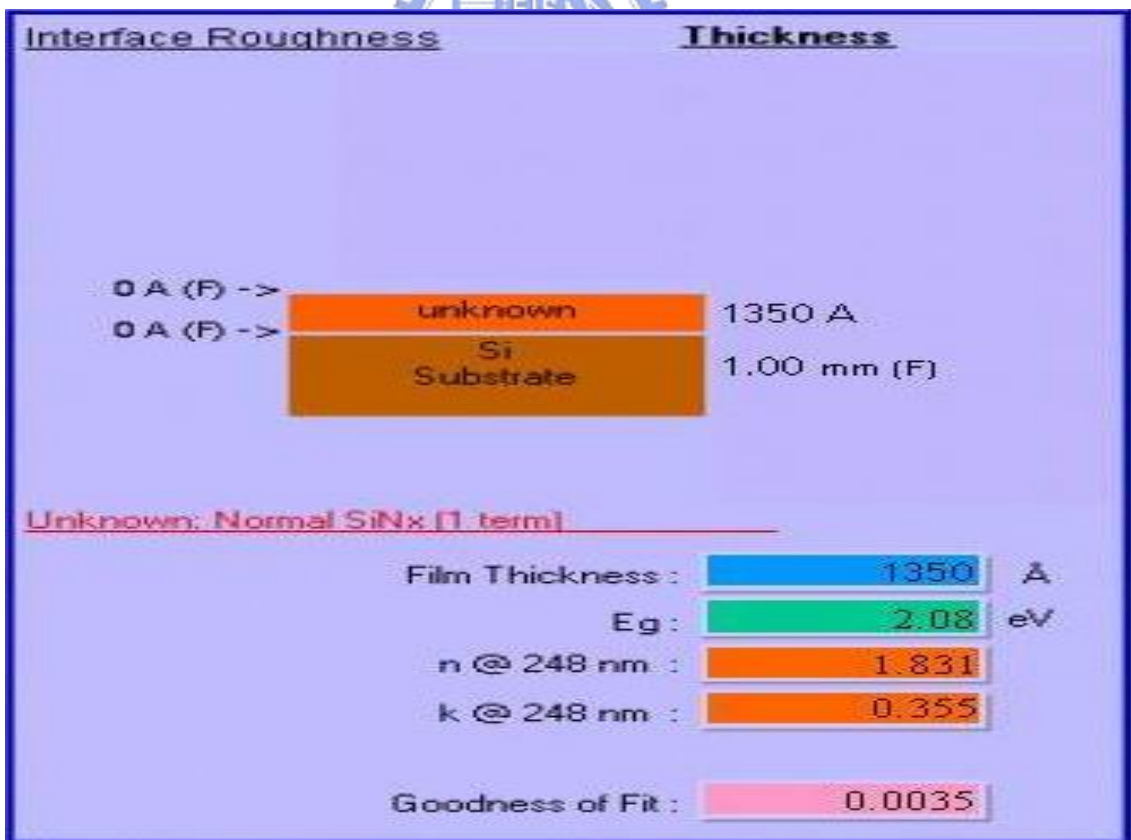
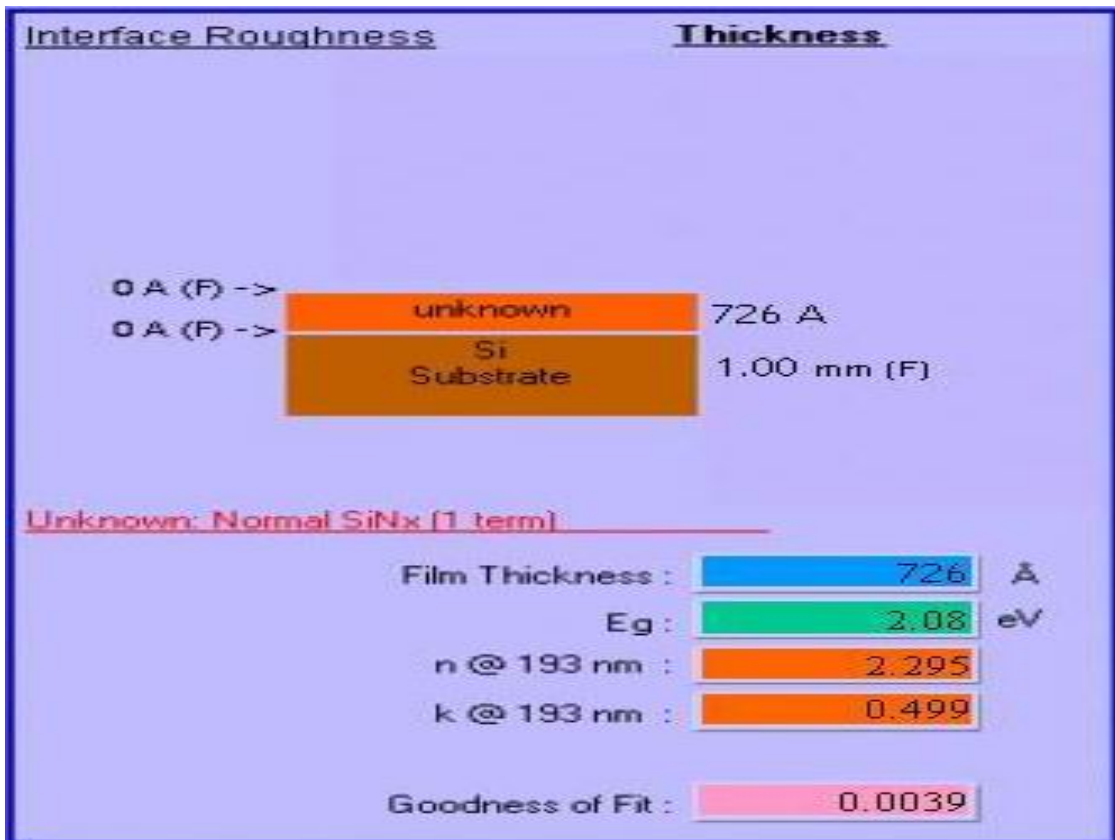


圖 4-8 193 nm 與 248 nm 嵌附層 MoSiN 之 n&k Analyzer 量測結果

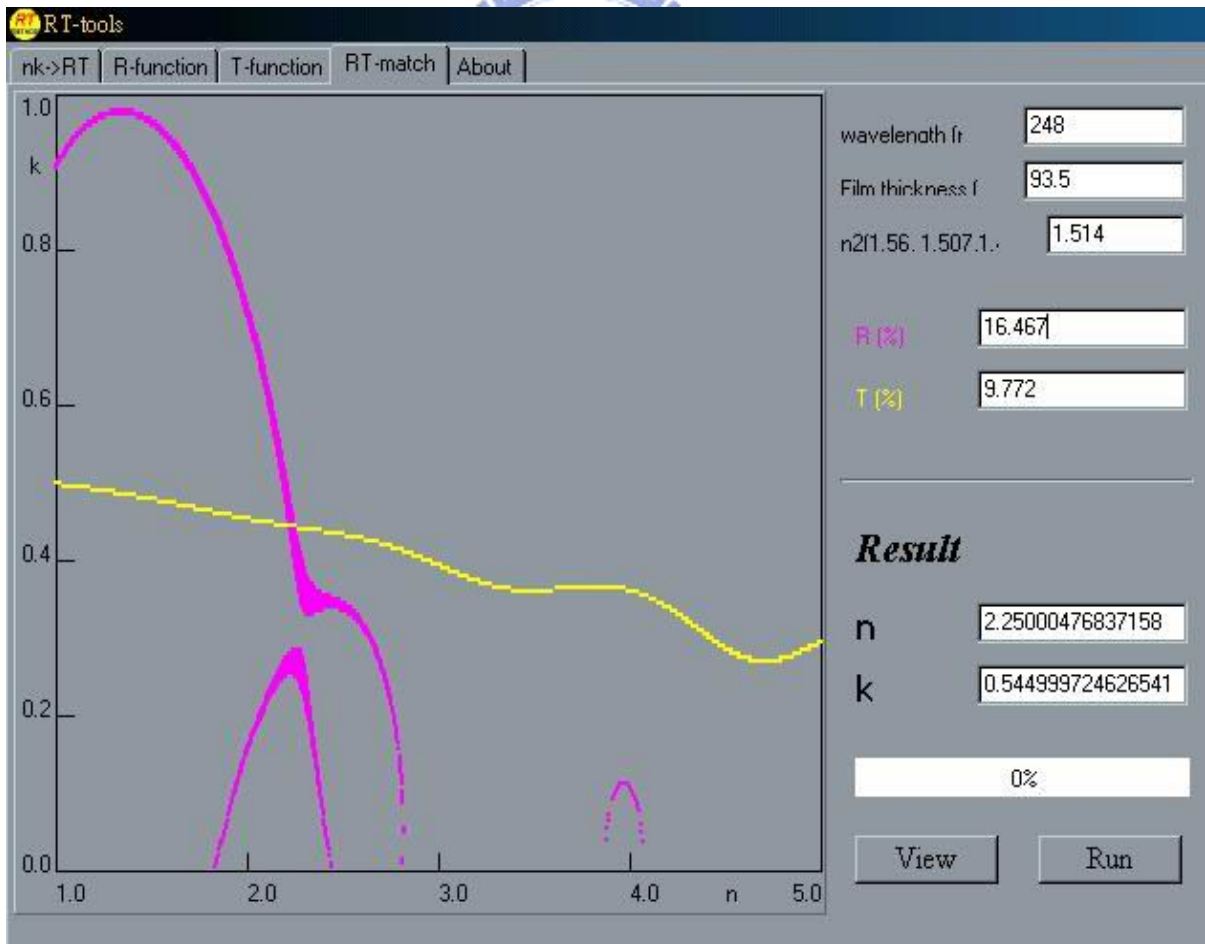
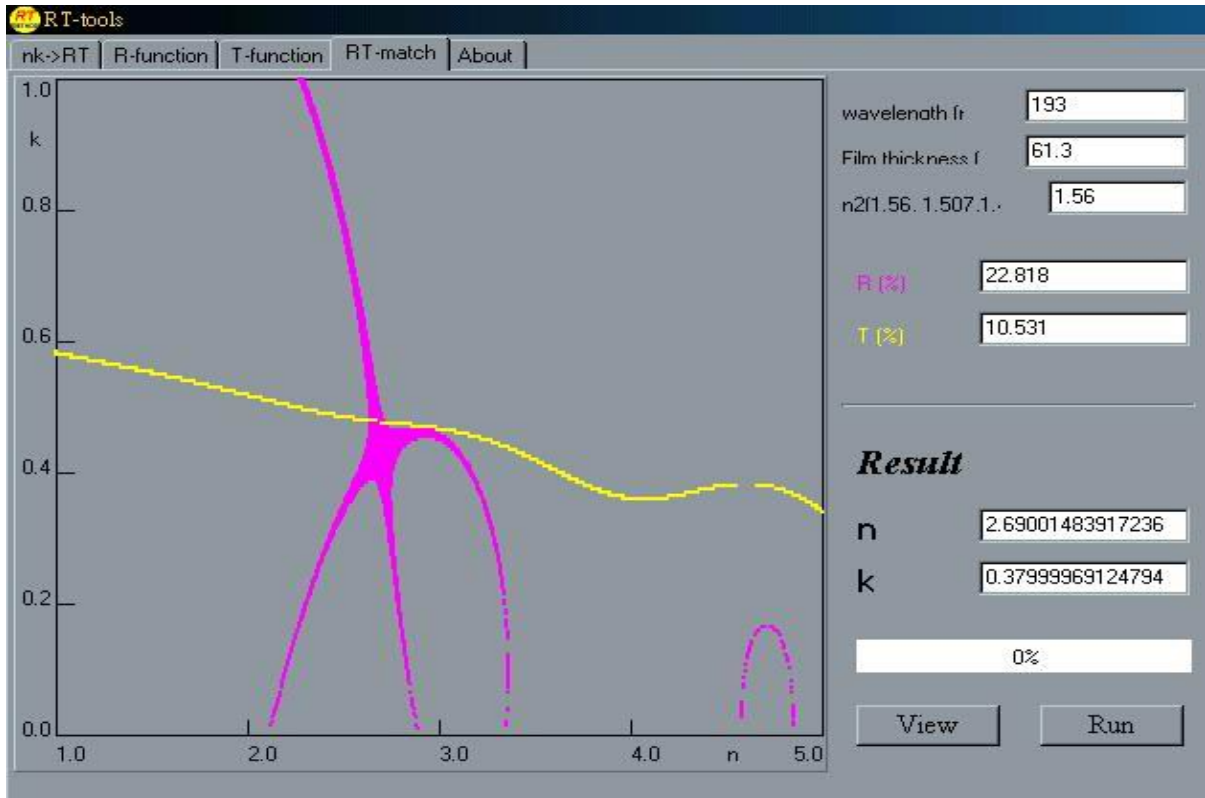


圖 4-9 193 nm 與 248 nm 嵌附層 Si_3N_4 之 R-T Method 計算結果

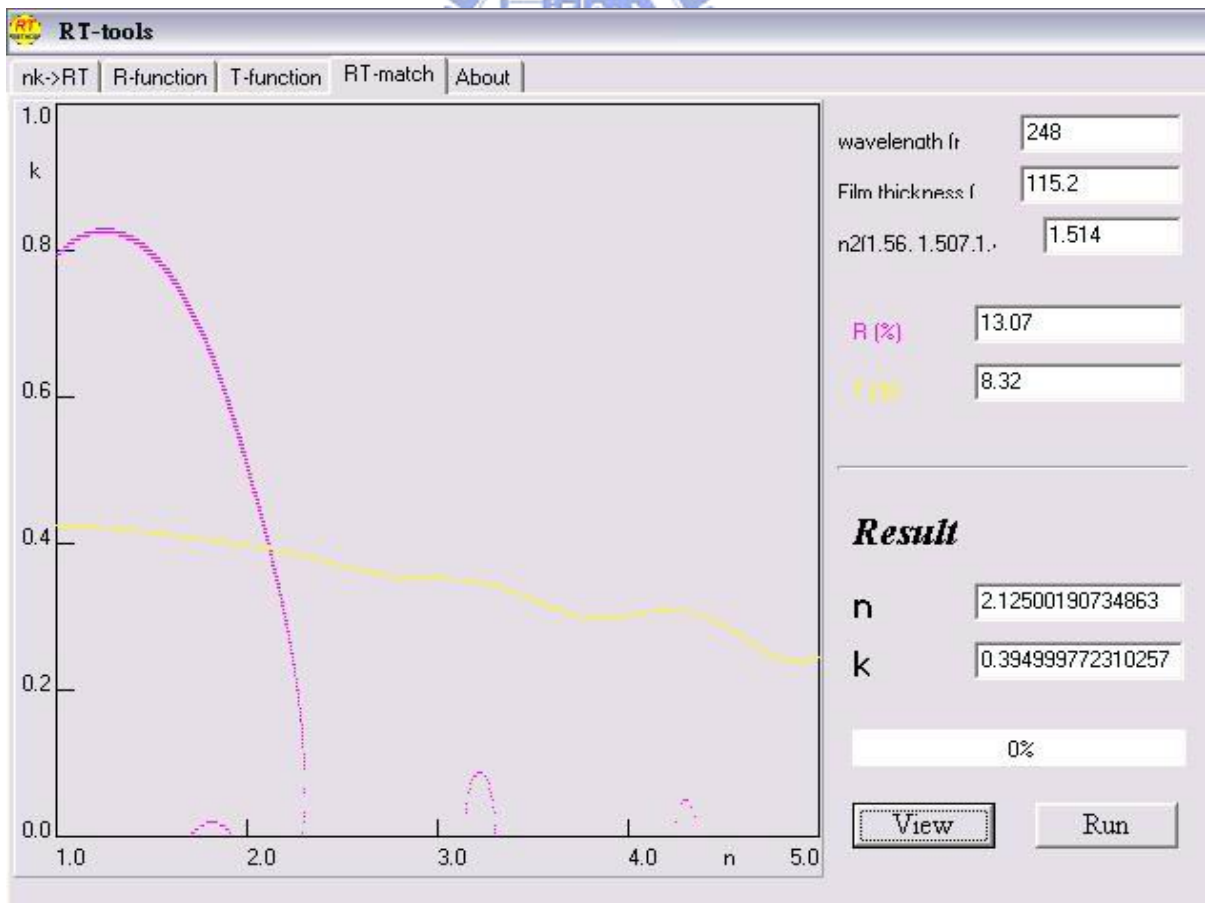
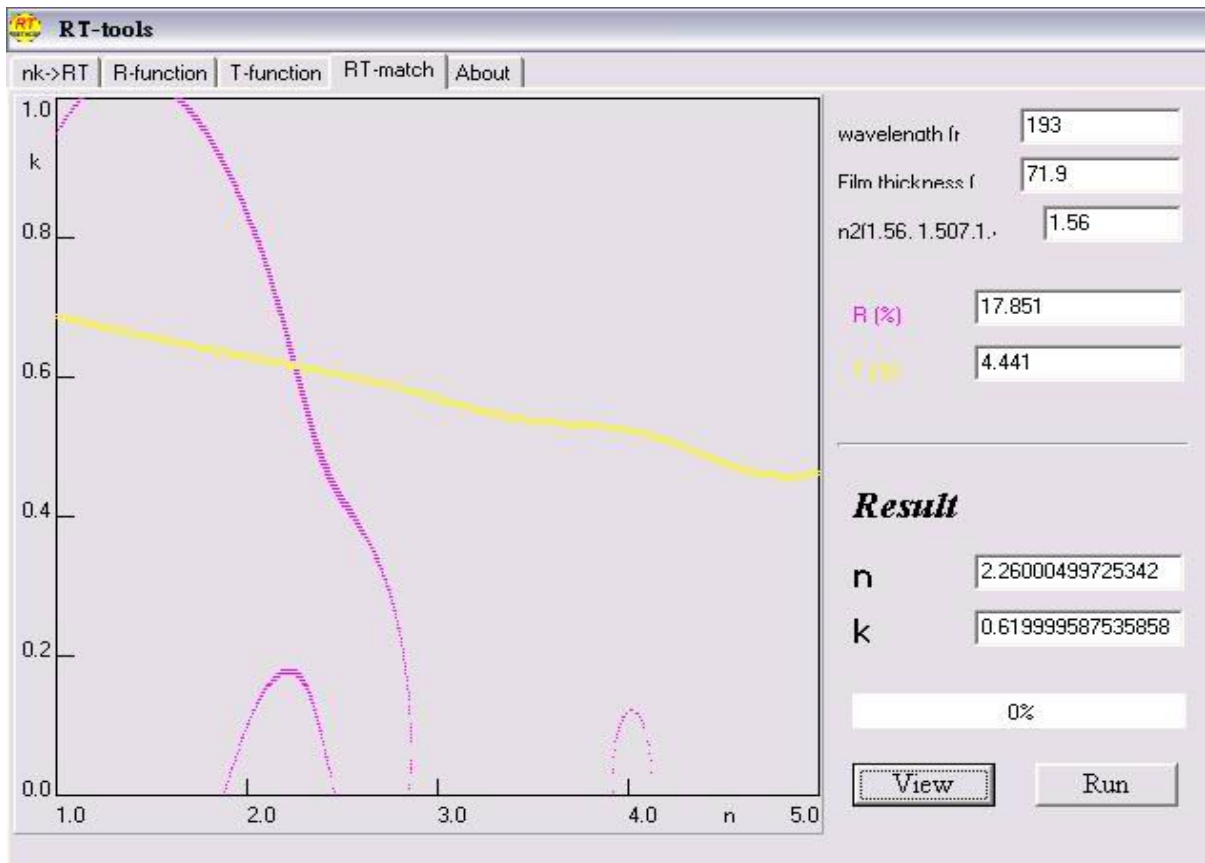


圖 4-10 193 nm 與 248 nm 嵌附層 TiSiN 之 R-T Method 計算結果

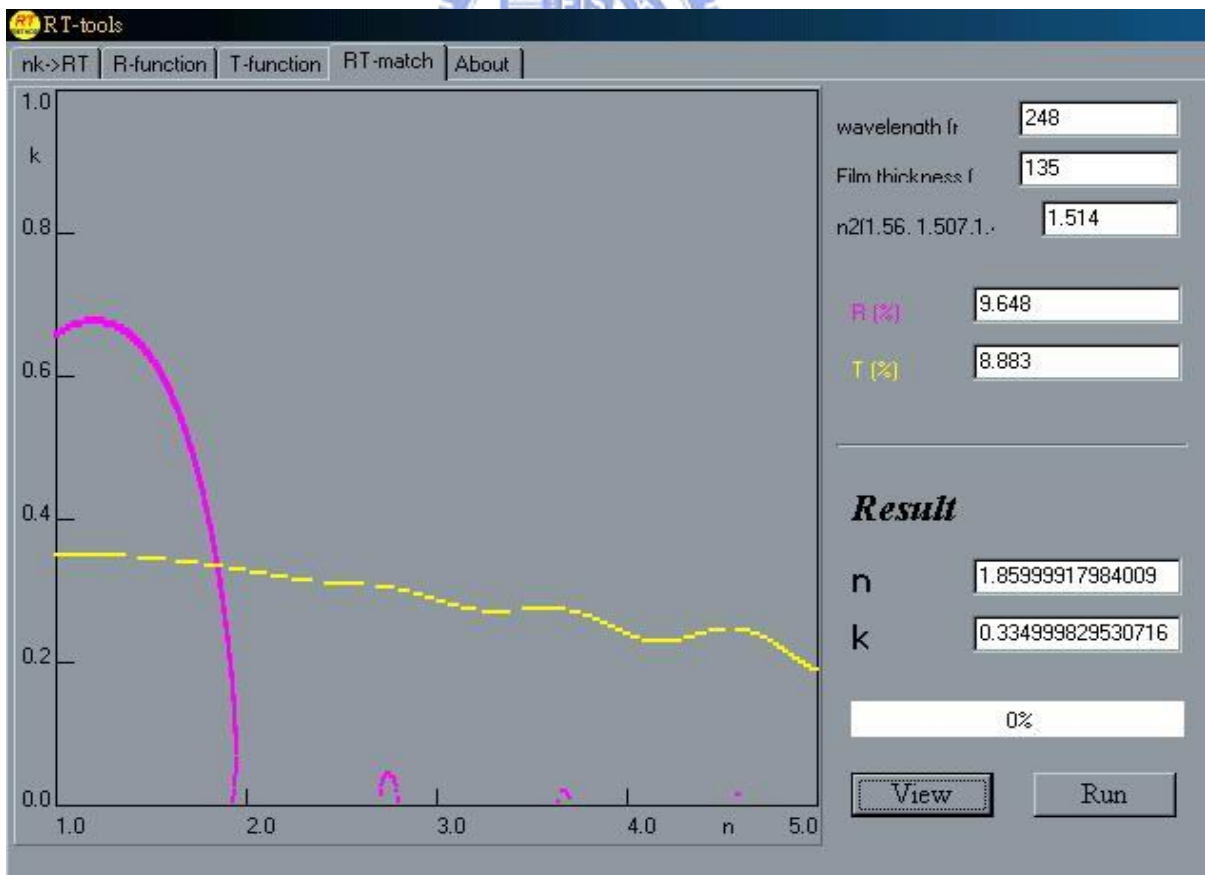
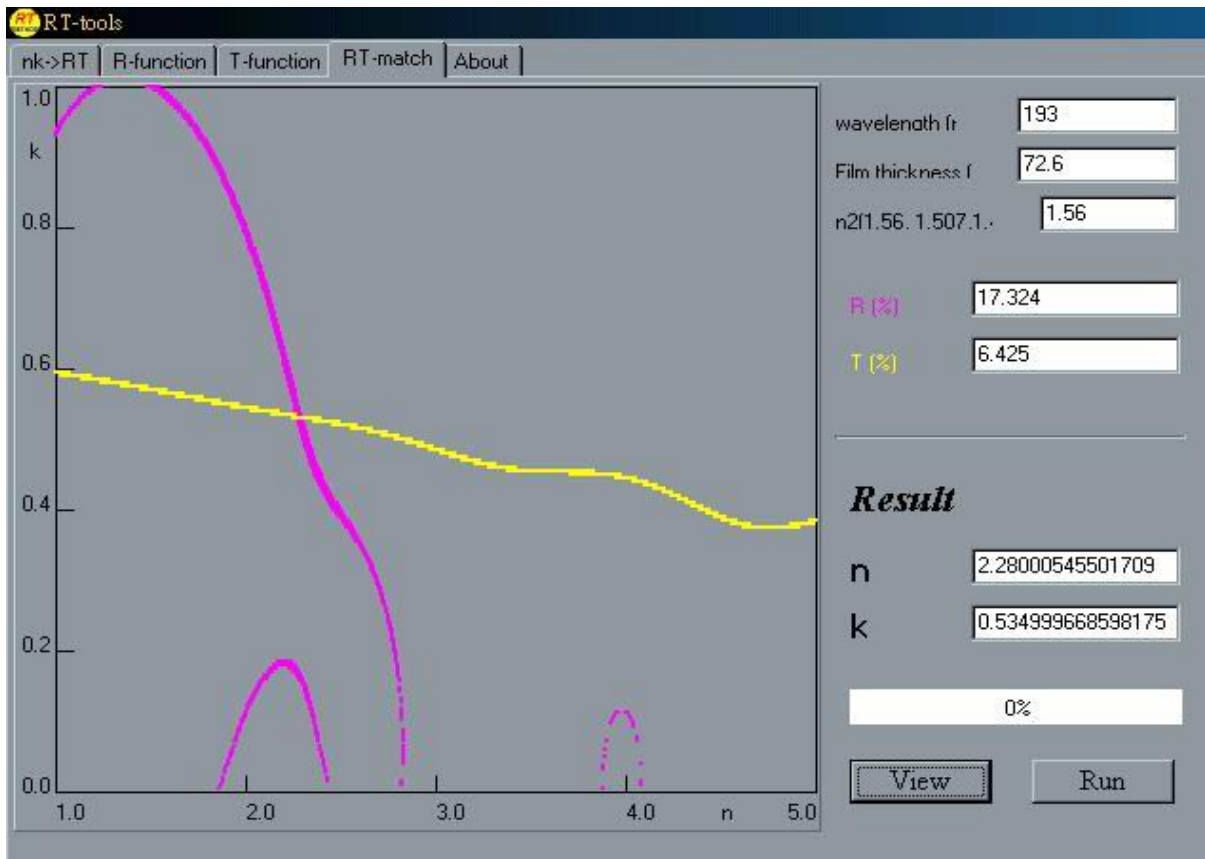


圖 4-11 193 nm 與 248 nm 嵌附層 MoSiN 之 R-T Method 計算結果

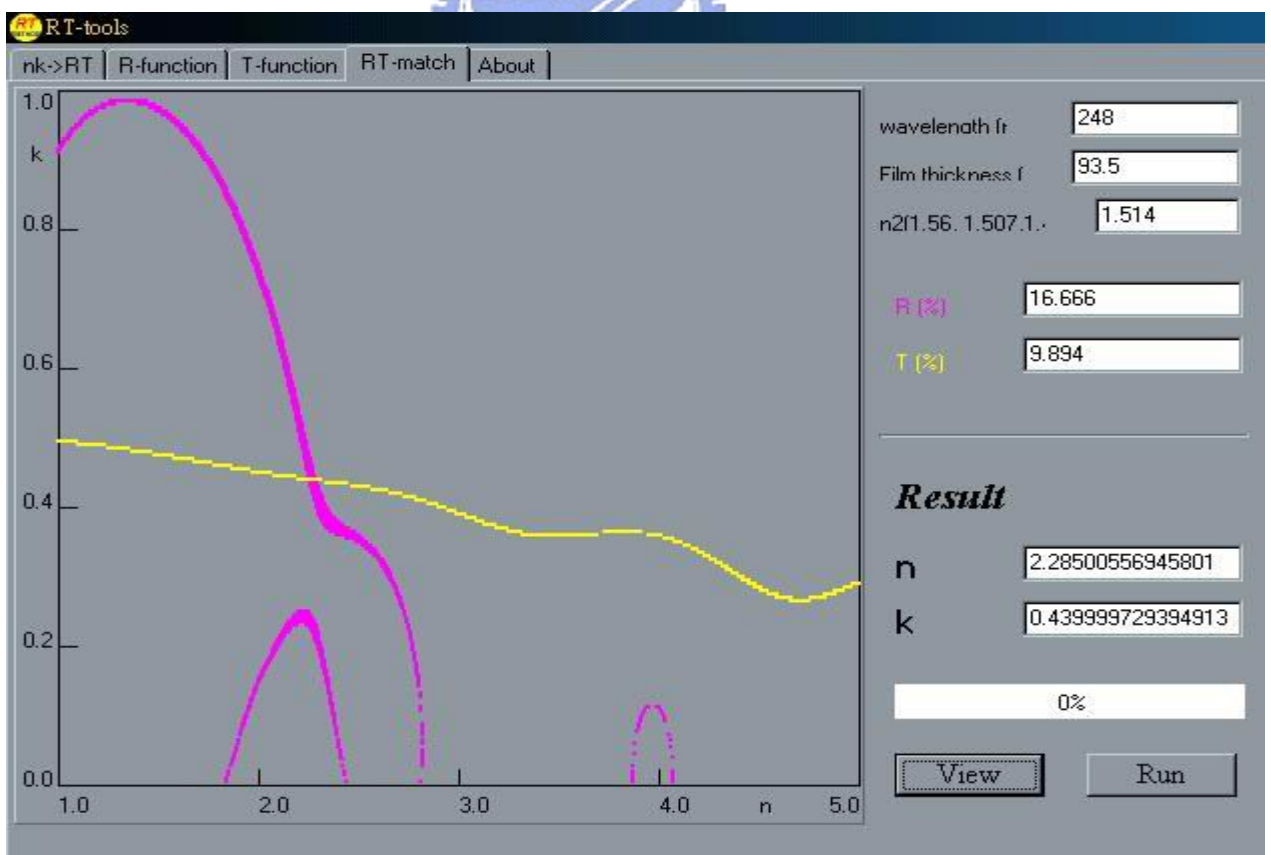
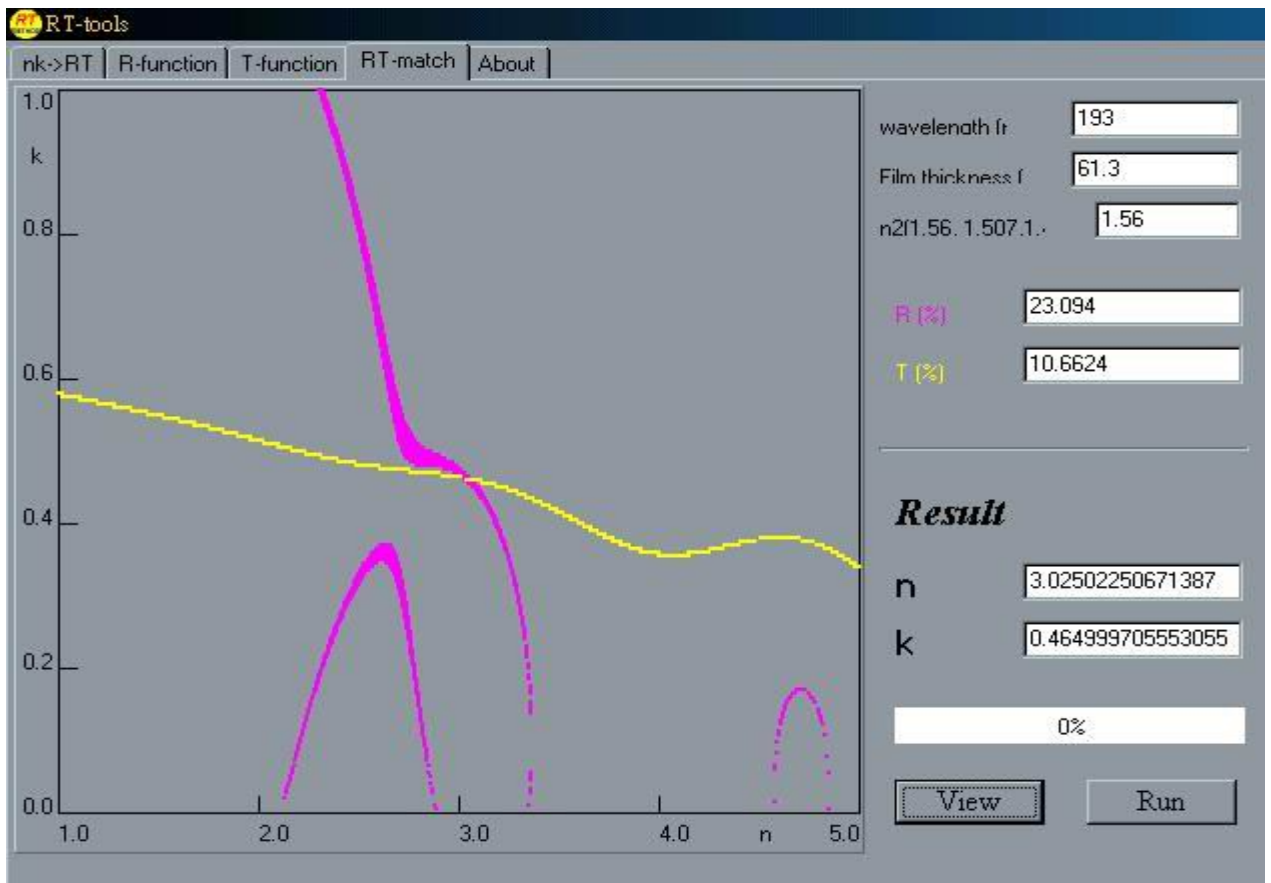


圖 4-12 193 nm 與 248 nm 嵌附層 Si_3N_4 之修正 R-T Method 計算結果

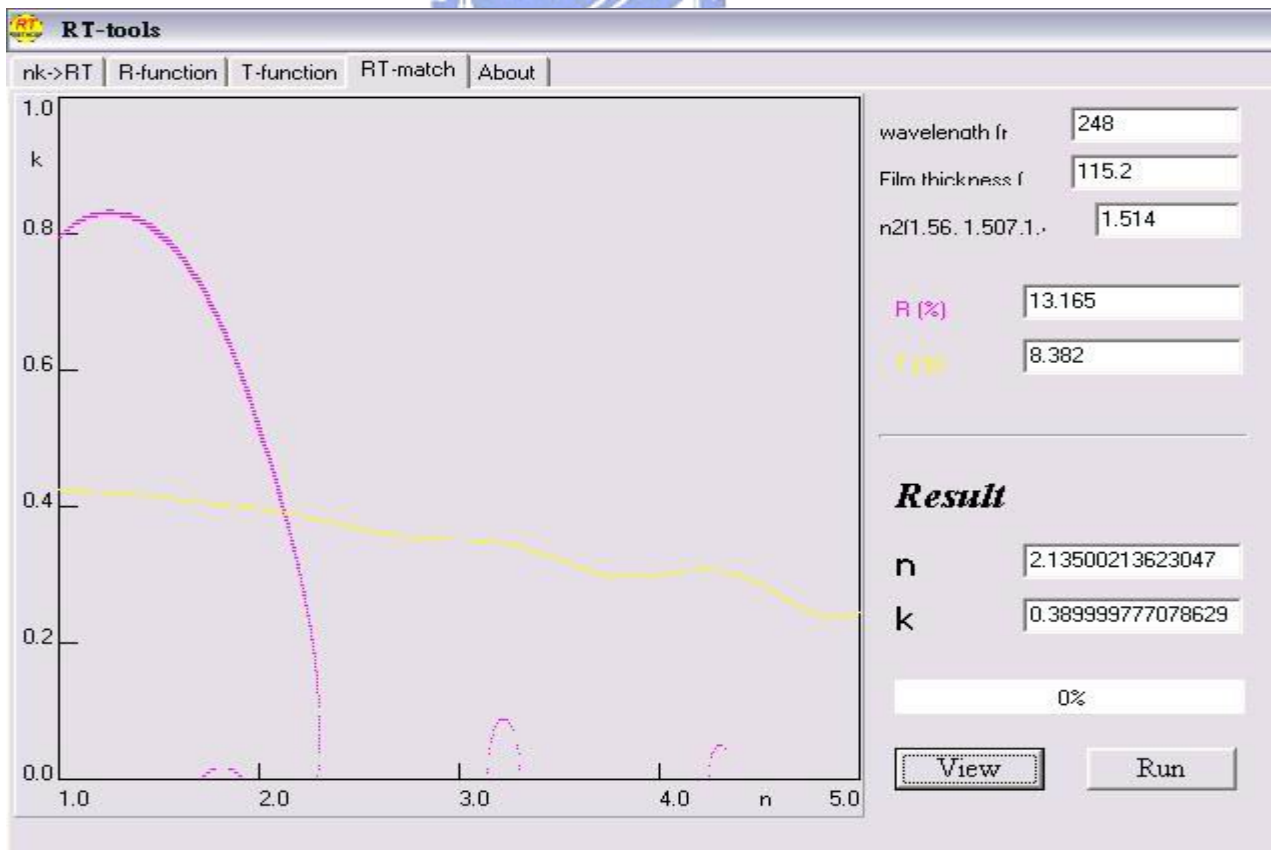
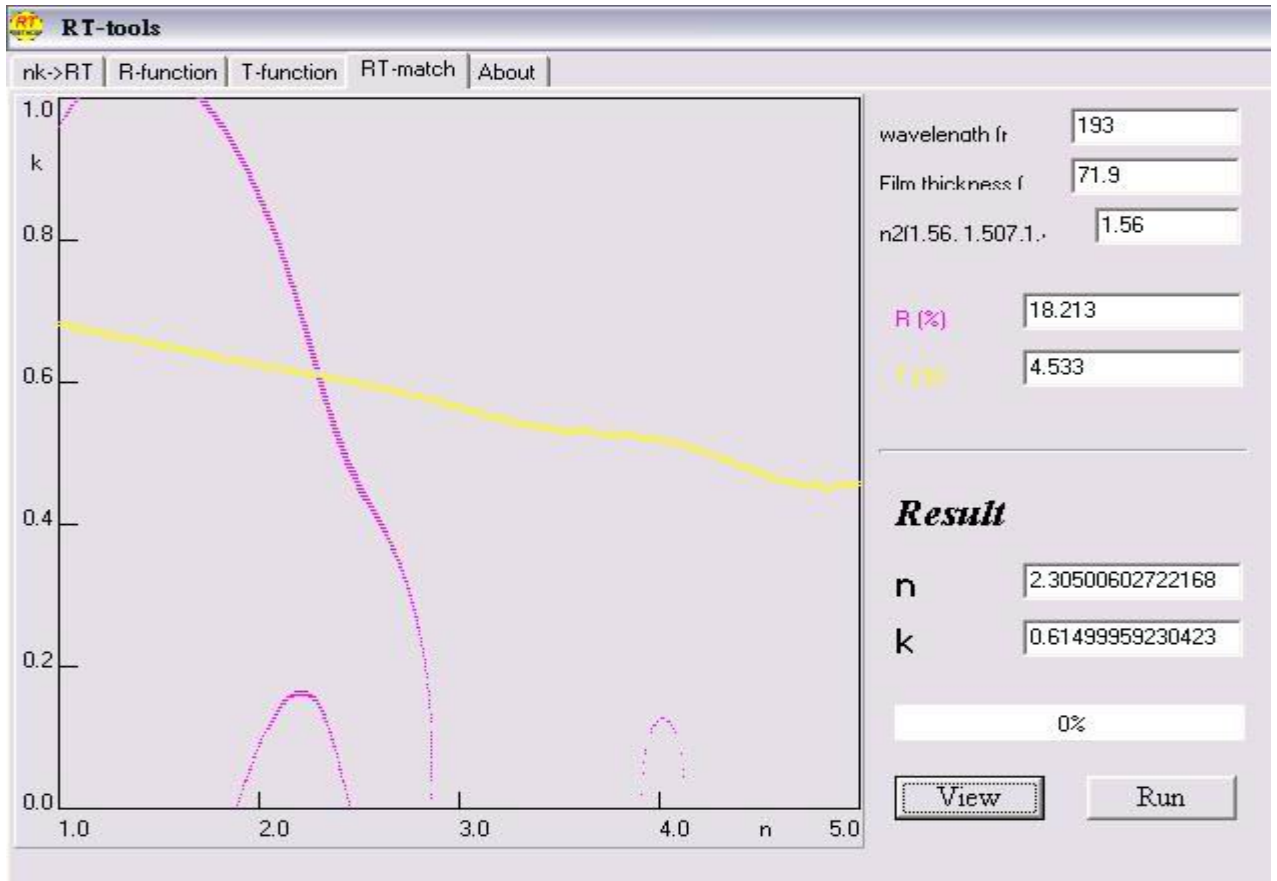


圖 4-13 193 nm 與 248 nm 嵌附層 TiSiN 之修正 R-T Method 計算結果

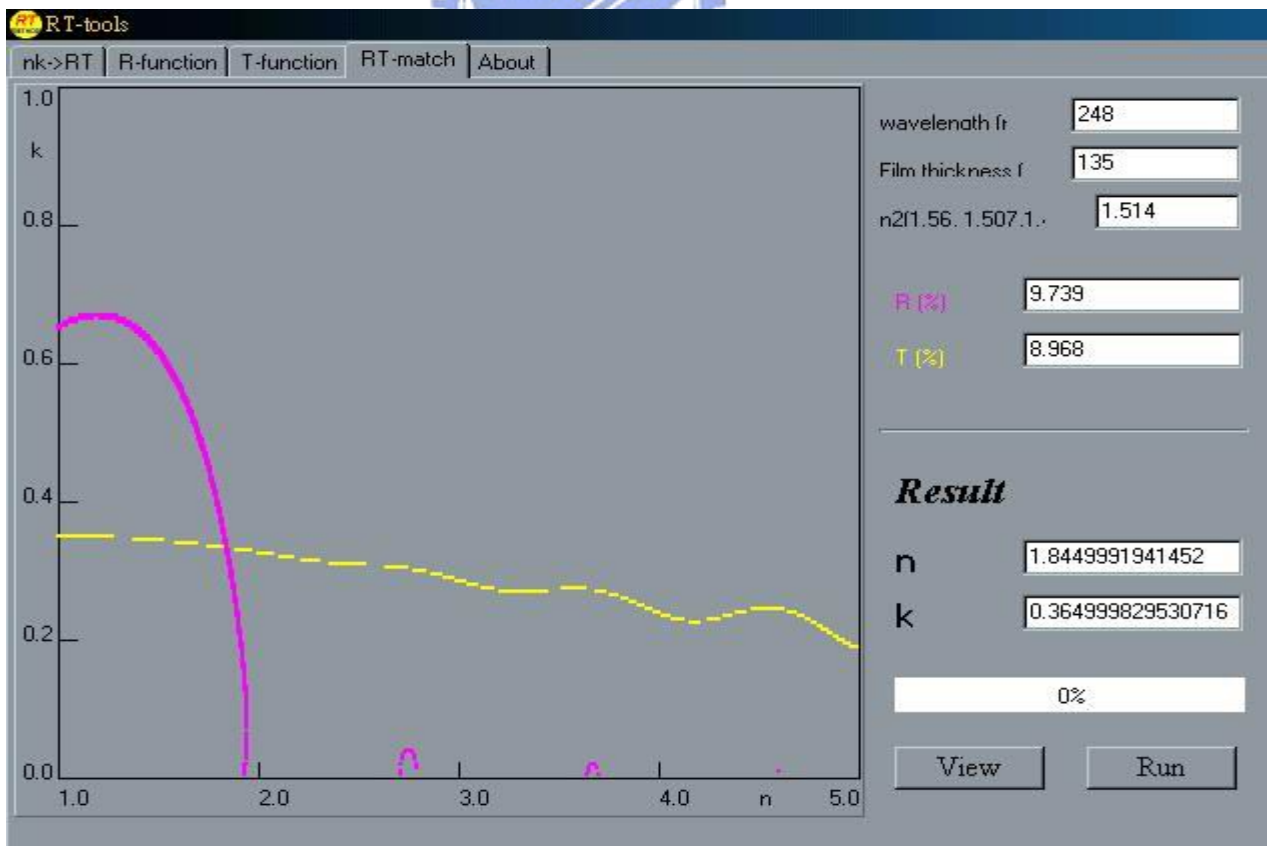
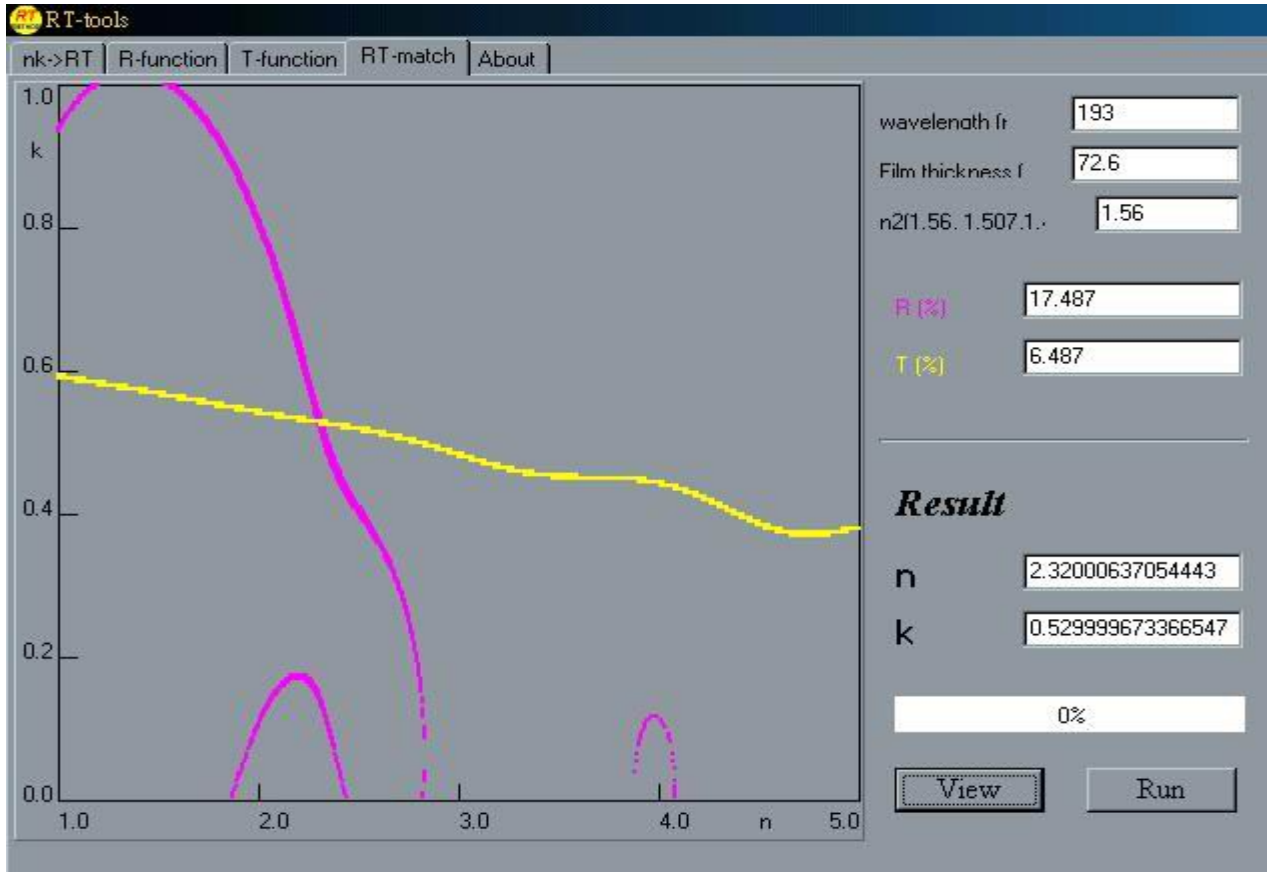


圖 4-14 193 nm 與 248 nm 嵌附層 MoSiN 之修正 R-T Method 計算結果

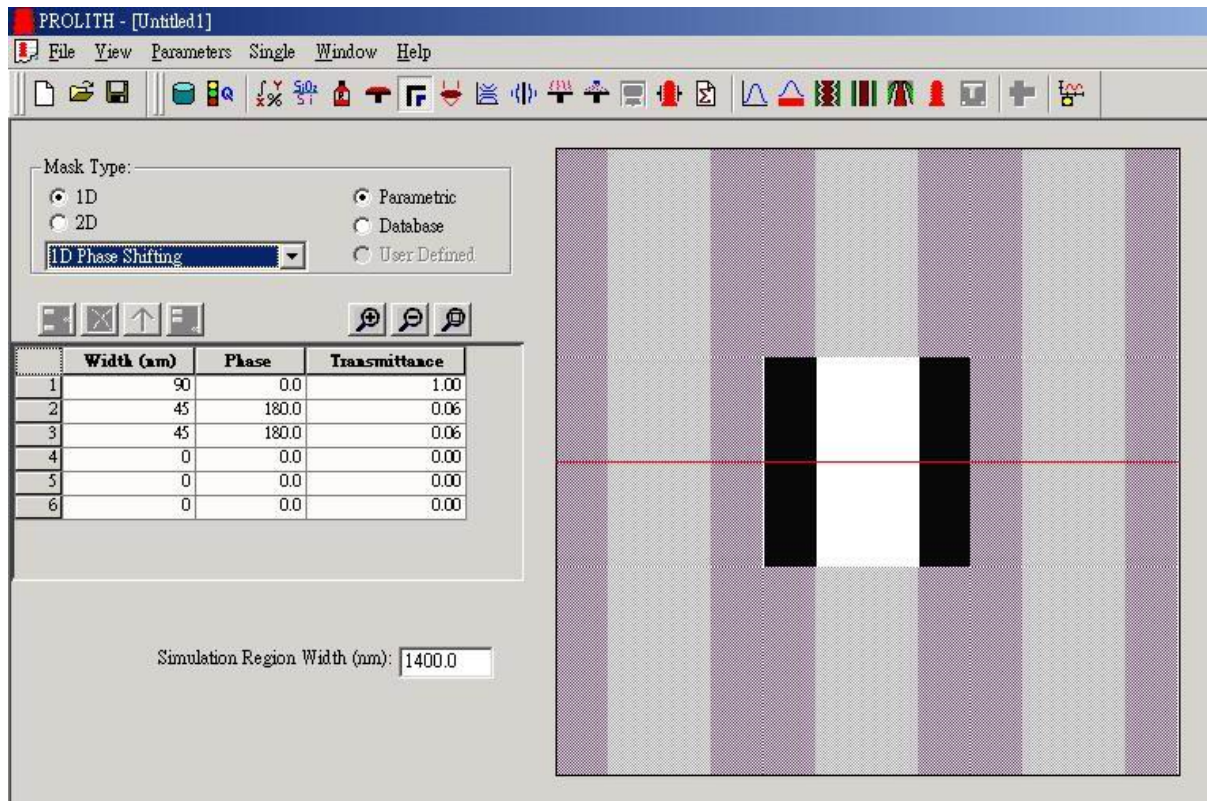


圖 4-15 相移圖罩之設計

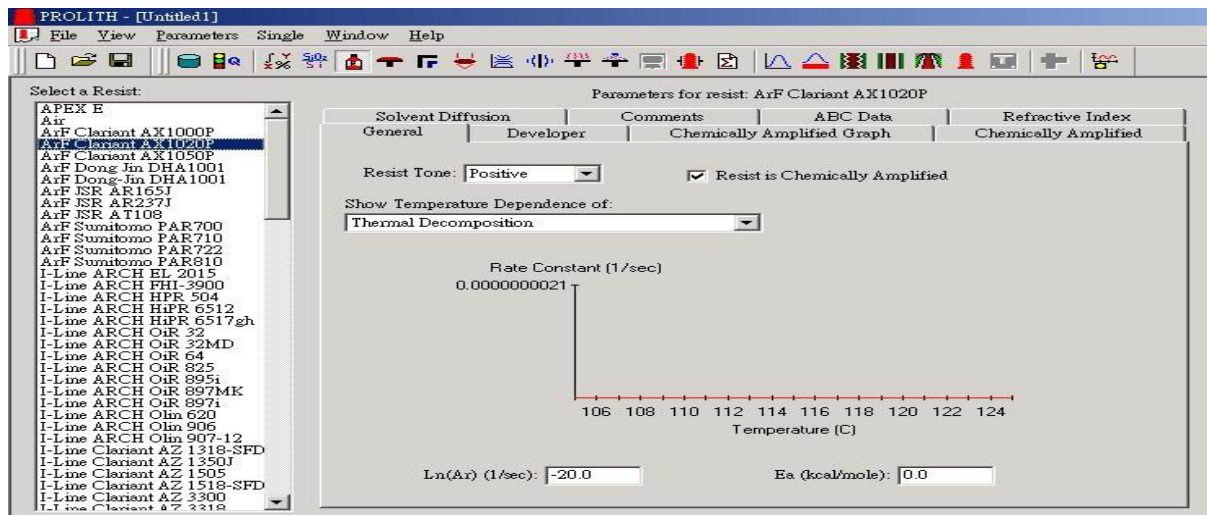


圖 4-16 模擬所預設阻劑之參數

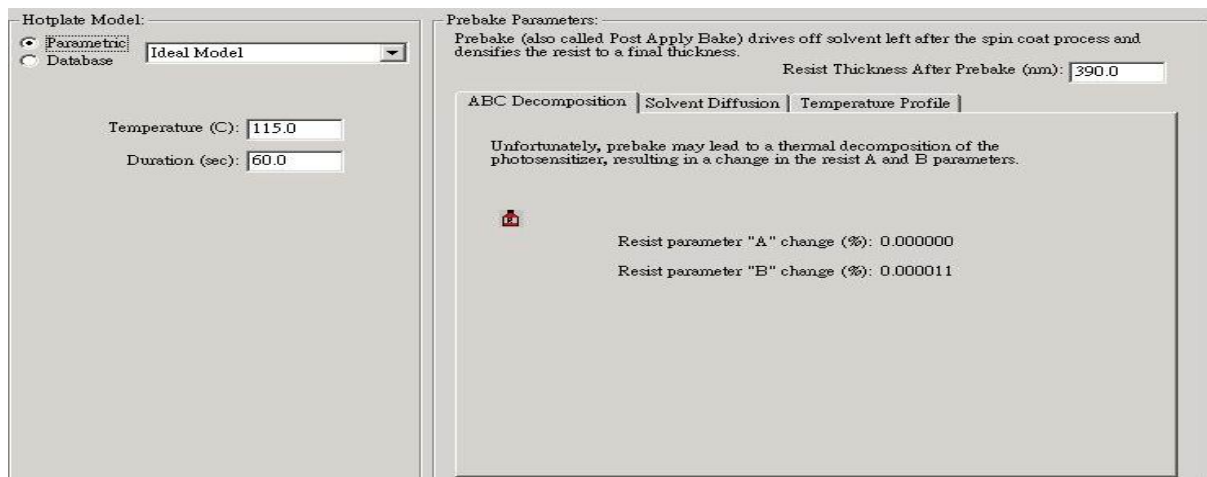


圖 4-17 模擬之預烤溫度/時間參數

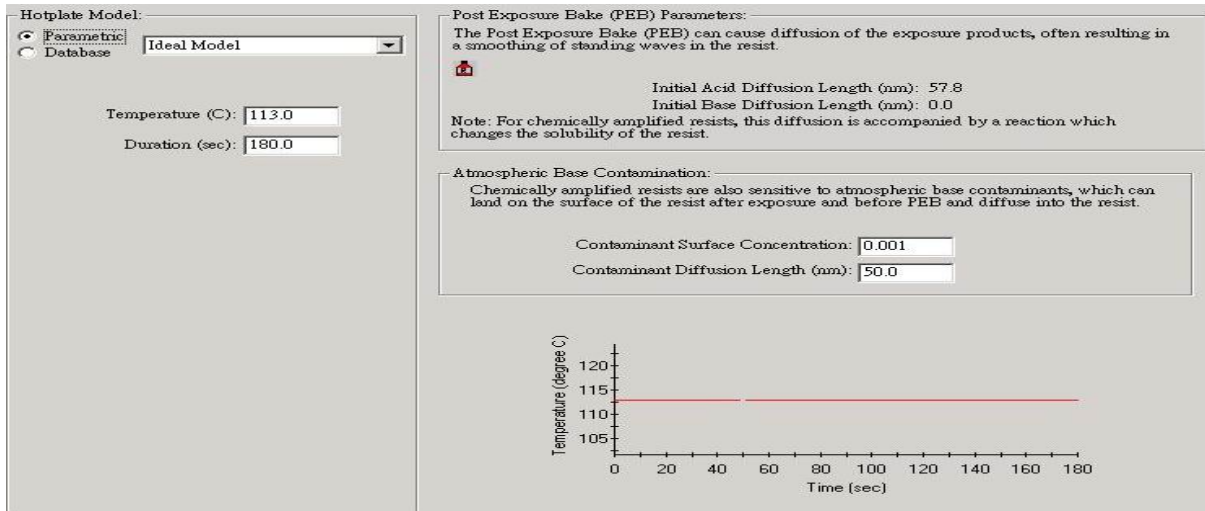


圖 4-18 模擬之照後烤溫度/時間參數

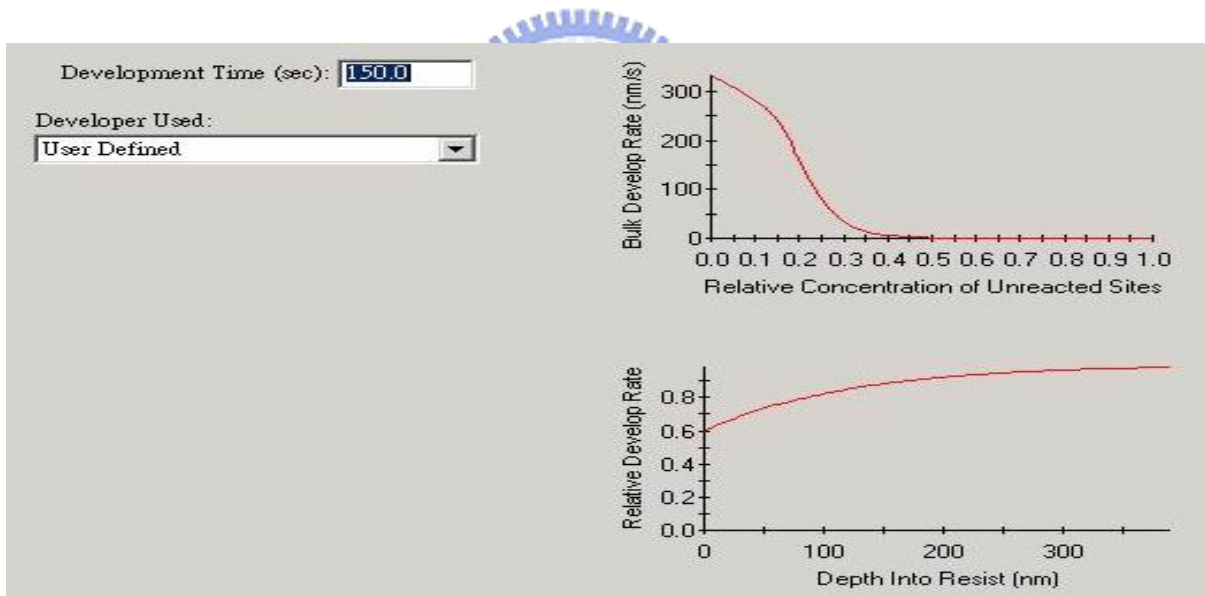
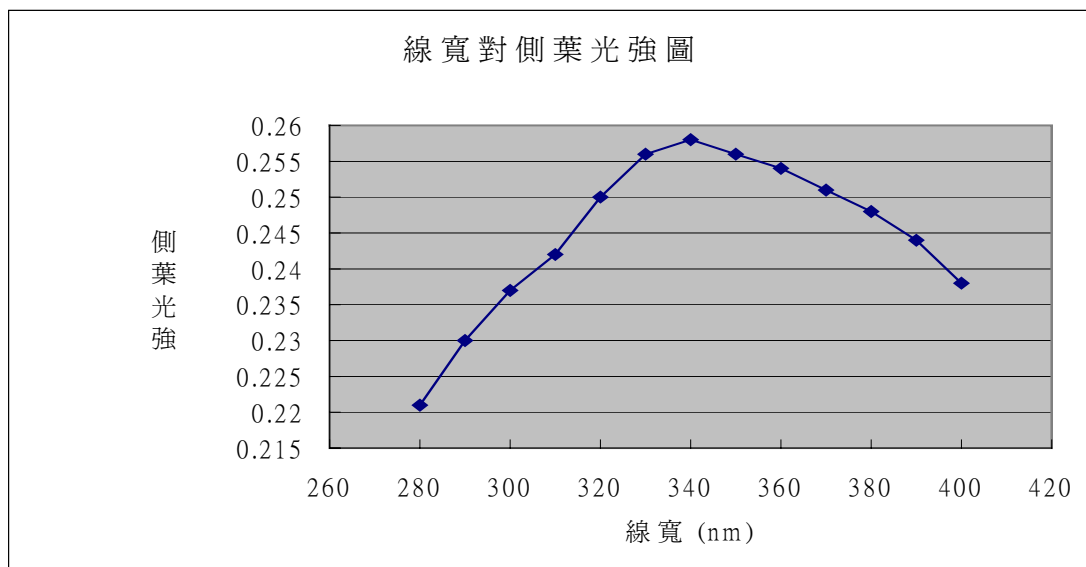


圖 4-19 模擬之顯影時間參數



圖 4-20 模擬計算之最佳照射劑量

(A)



(B)

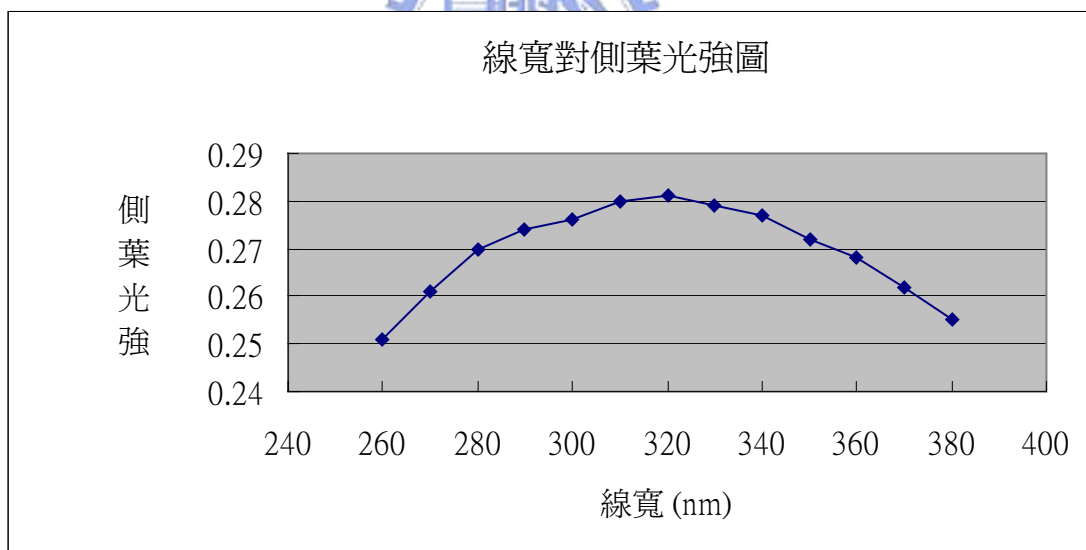


圖 4-21 二孔平行位向之線寬對側葉光強關係：

(A) 隙寬 110 nm；(B) 隙寬 90 nm

($T=10\%$ ，孔距=0.6，孔徑=0.3， $NA=0.8$ ，隙寬+線寬=間距(Pitch))

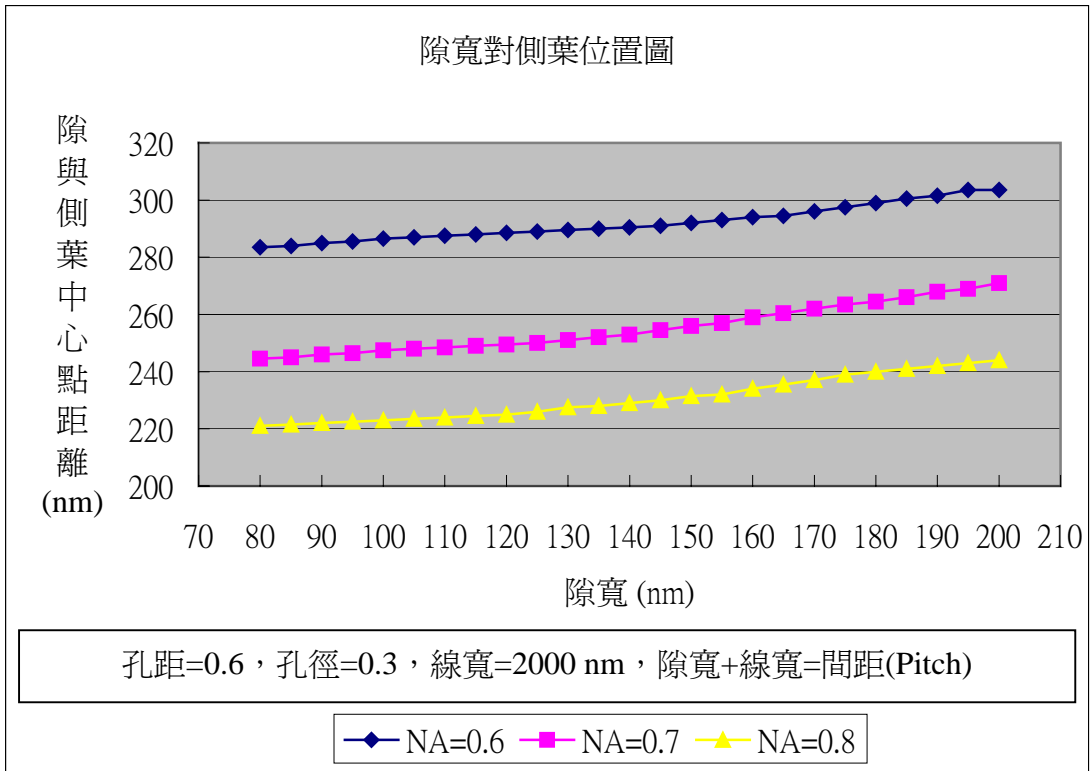


圖 4-22 二孔平行位向之聚光當量對側葉位置關係

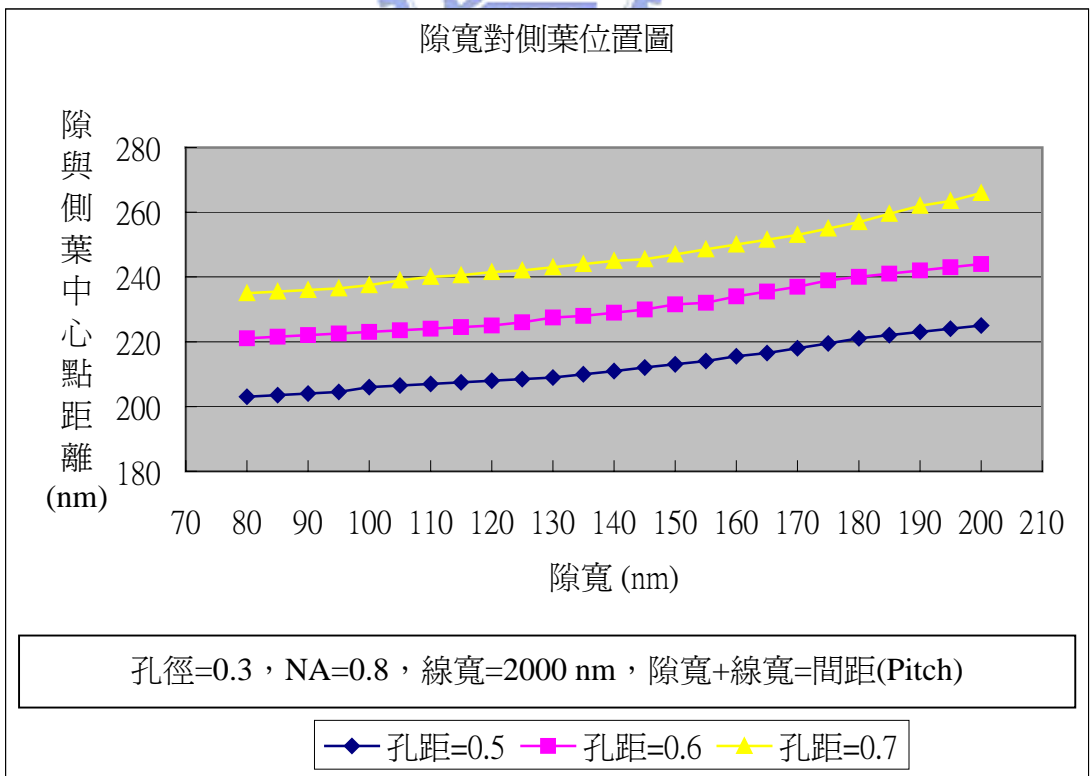


圖 4-23 二孔平行位向之孔距對側葉位置關係

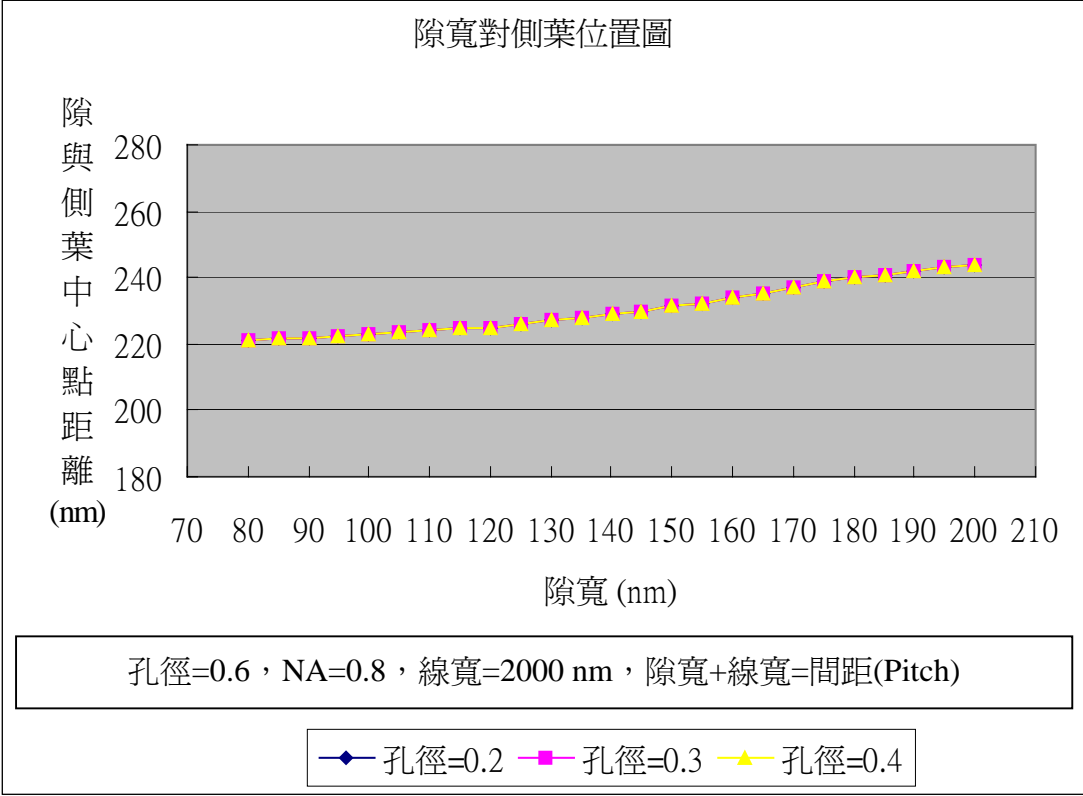
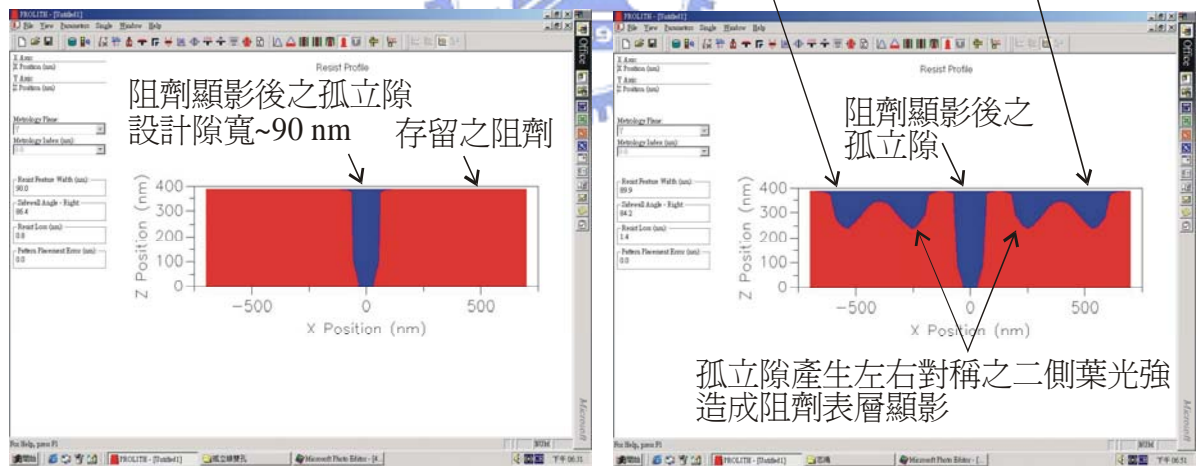
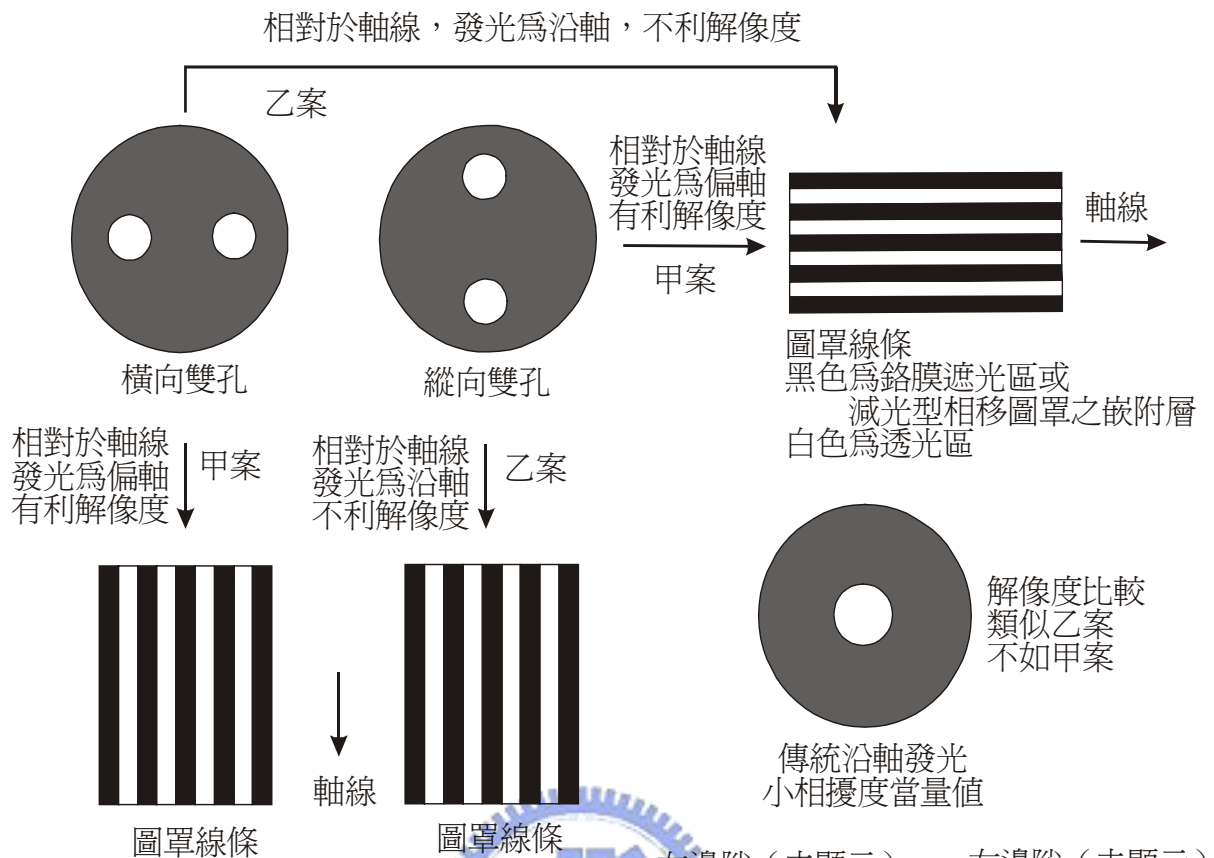


圖 4-24 二孔平行位向之孔徑對側葉位置關係



有利解像度之甲案
隙(Space)較細且無側葉光強

不利解像度之乙案
隙較粗且有甚強之側葉光強

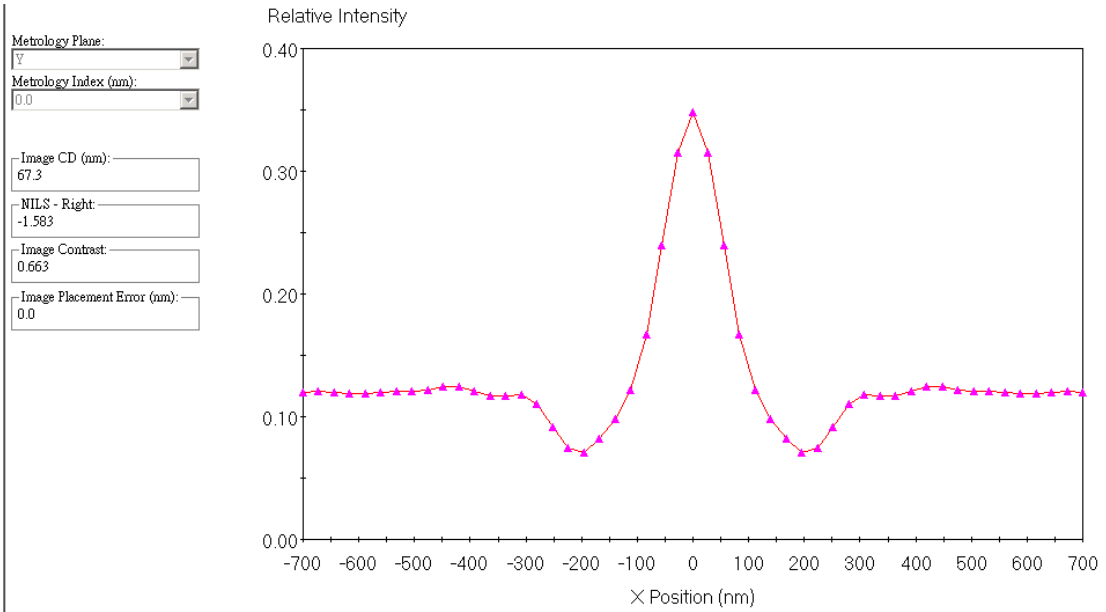
以PROLITH (V. 8.0)微影模擬軟體模擬結果示例：

晶圓上正型阻劑顯影後剖面圖

雙孔孔徑0.3，雙孔孔距0.5，波長193 nm，門檻光強0.3，聚光當量(NA) 0.8
嵌附式減光型相移圖罩(EAPSM)嵌附層透射率T%=6

圖 4-25 二孔發光對圖案線條垂直與平行時之成像結果

(A)



(B)

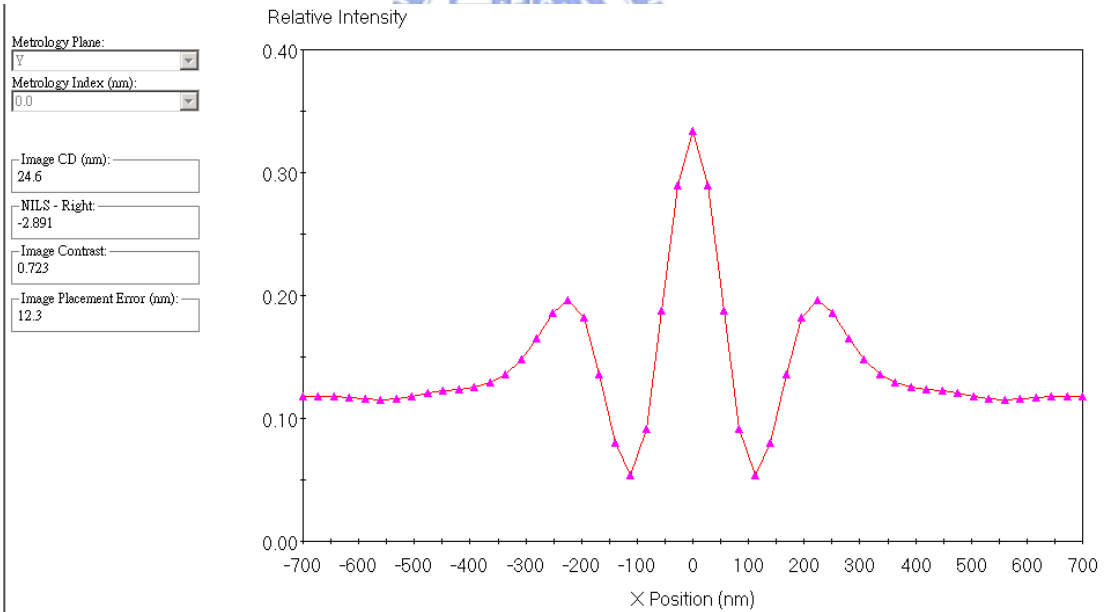
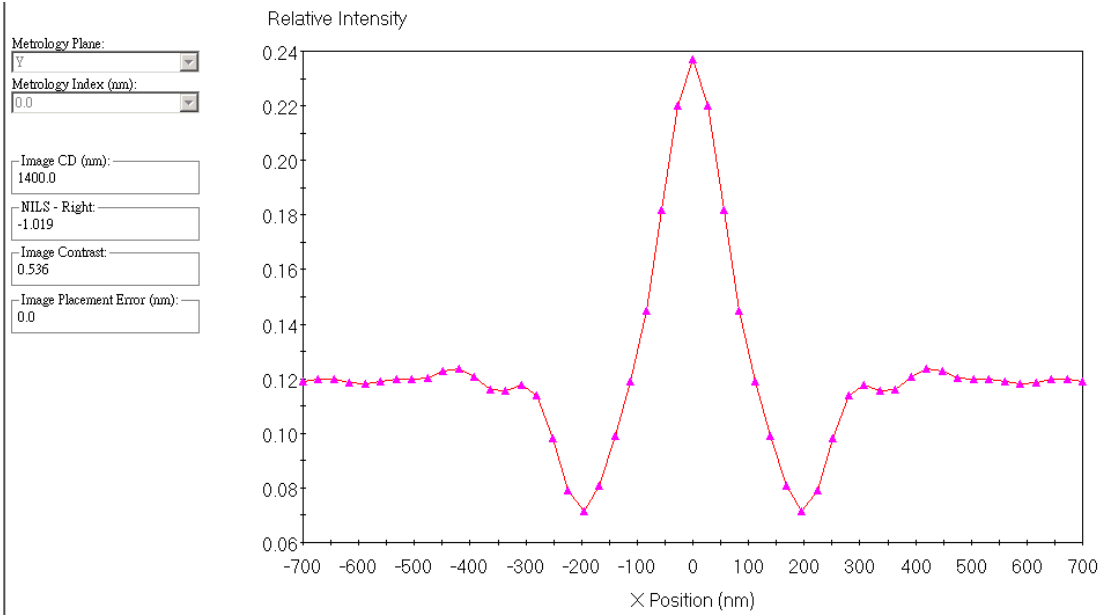


圖 4-26 二孔發光對 110nm 孤立隙之空間影像：

(A) 垂直位向發光；(B) 平行位向發光

(T=10% ，孔距=0.6，孔徑=0.3，NA=0.8，線寬=2000 nm)

(A)



(B)

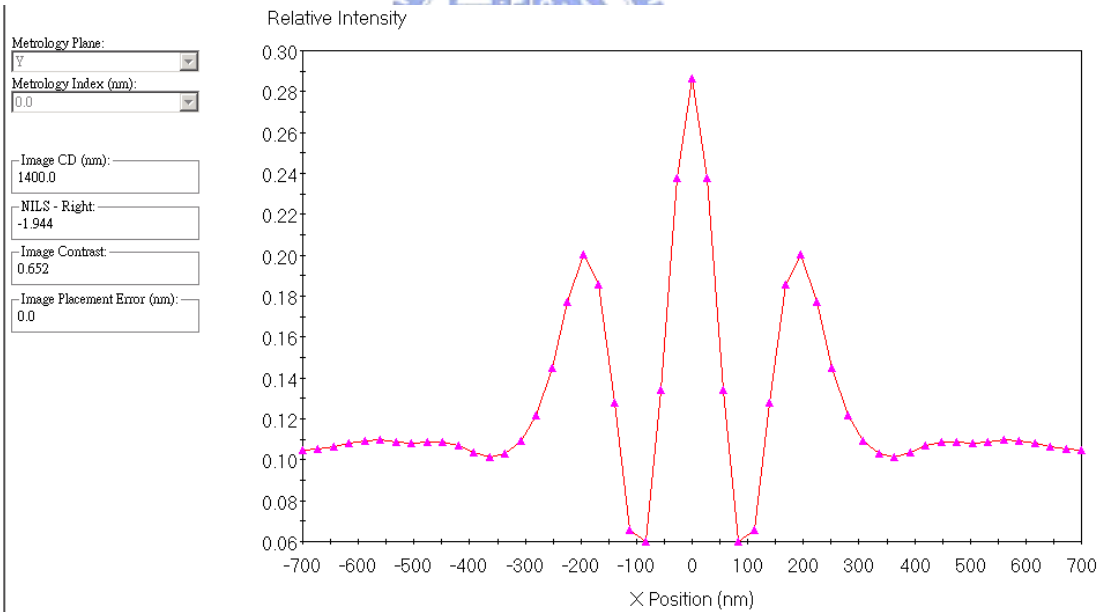


圖 4-27 二孔發光對 90nm 孤立隙之空間影像：

(A) 垂直位向發光；(B) 平行位向發光

($T=10\%$ ，孔距=0.6，孔徑=0.3， $NA=0.8$ ，線寬=2000 nm)

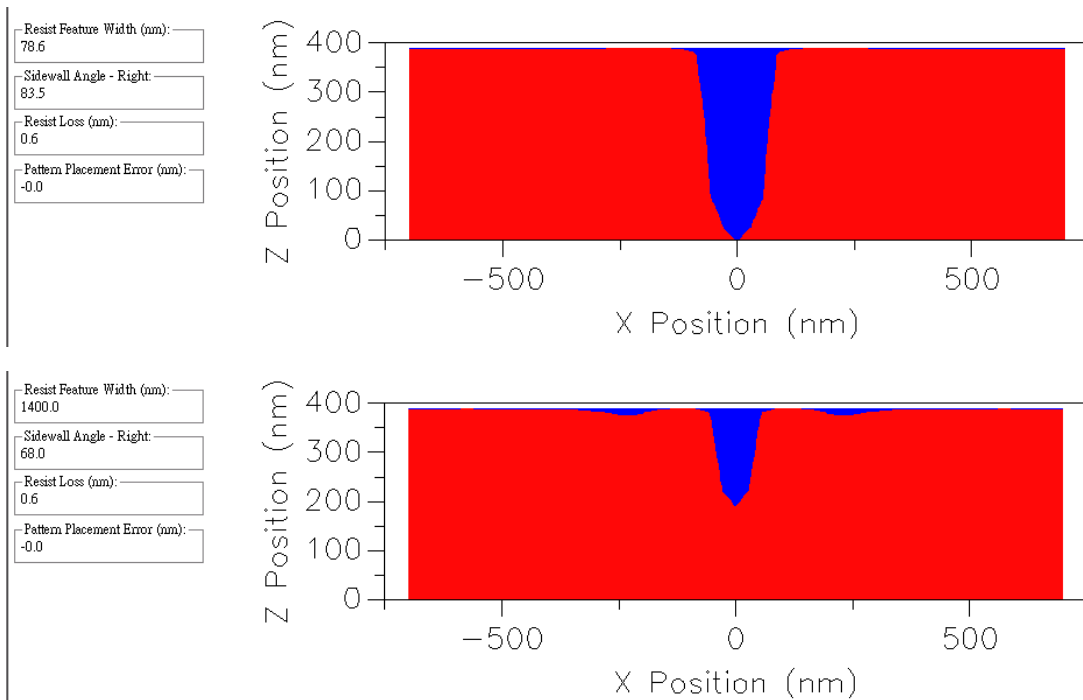


圖 4-28 二孔垂直(上)與平行位向(下)對 110nm 孤立隙之阻劑輪廓
 (T=10% , 孔距=0.6, 孔徑=0.3, NA=0.8, 線寬=2000 nm)

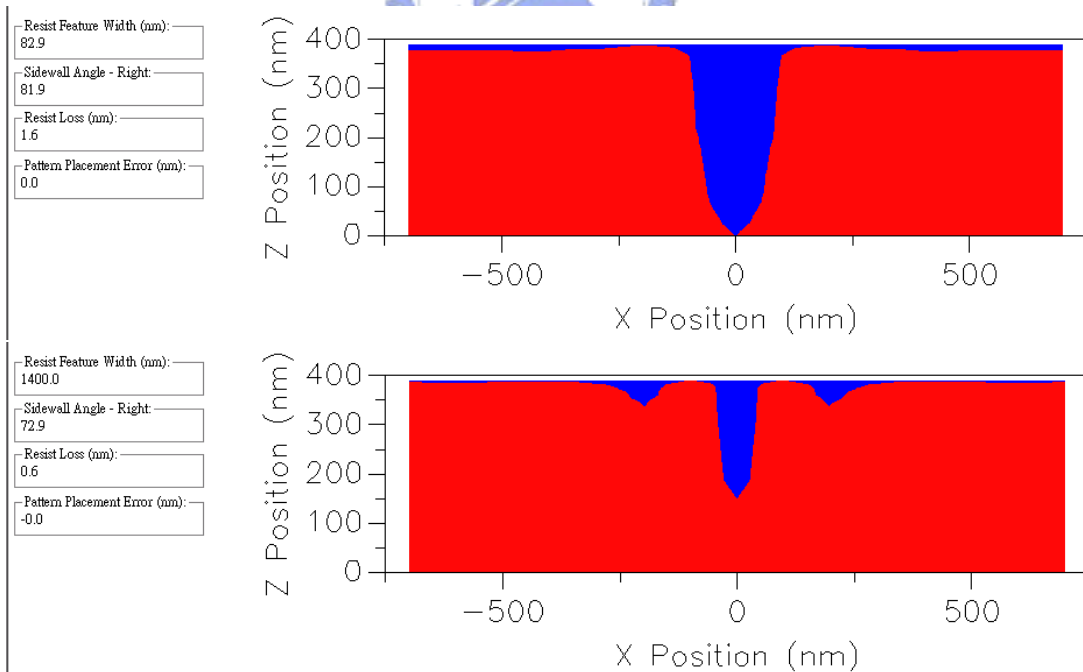


圖 4-29 二孔垂直(上)與平行位向(下)對 90nm 孤立隙之阻劑輪廓
 (T=10% , 孔距=0.6, 孔徑=0.3, NA=0.8, 線寬=2000 nm)

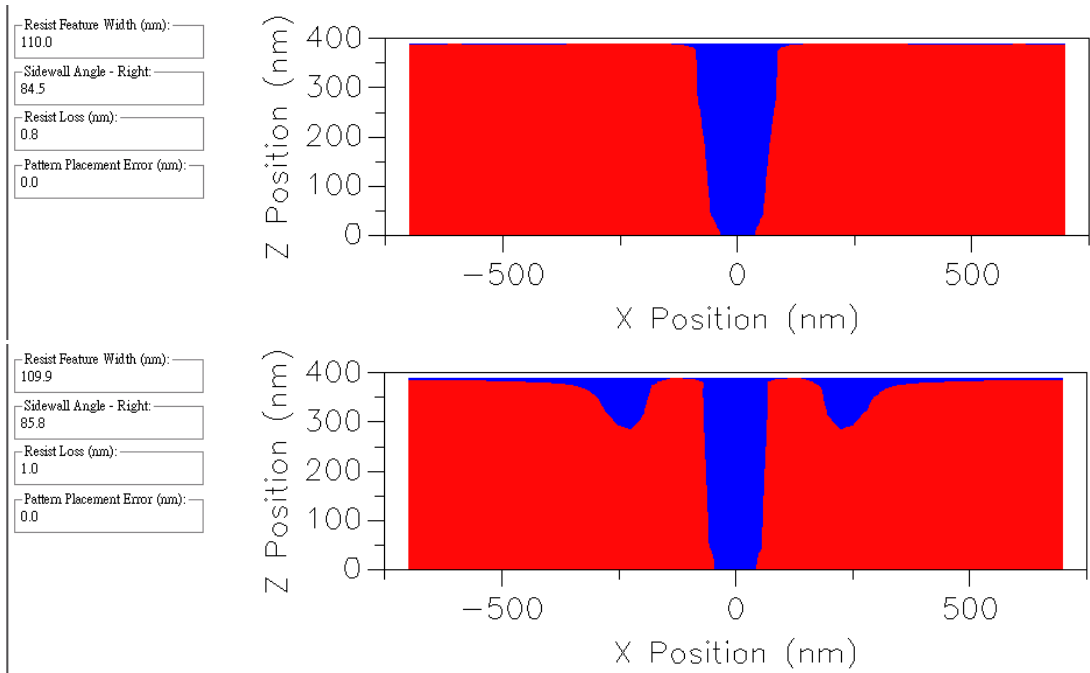


圖 4-30 二孔垂直(上)與平行位向(下)對 110nm 孤立隙之阻劑輪廓
($T=10\%$, 孔距=0.6, 孔徑=0.3, $NA=0.8$, 線寬=2000 nm)

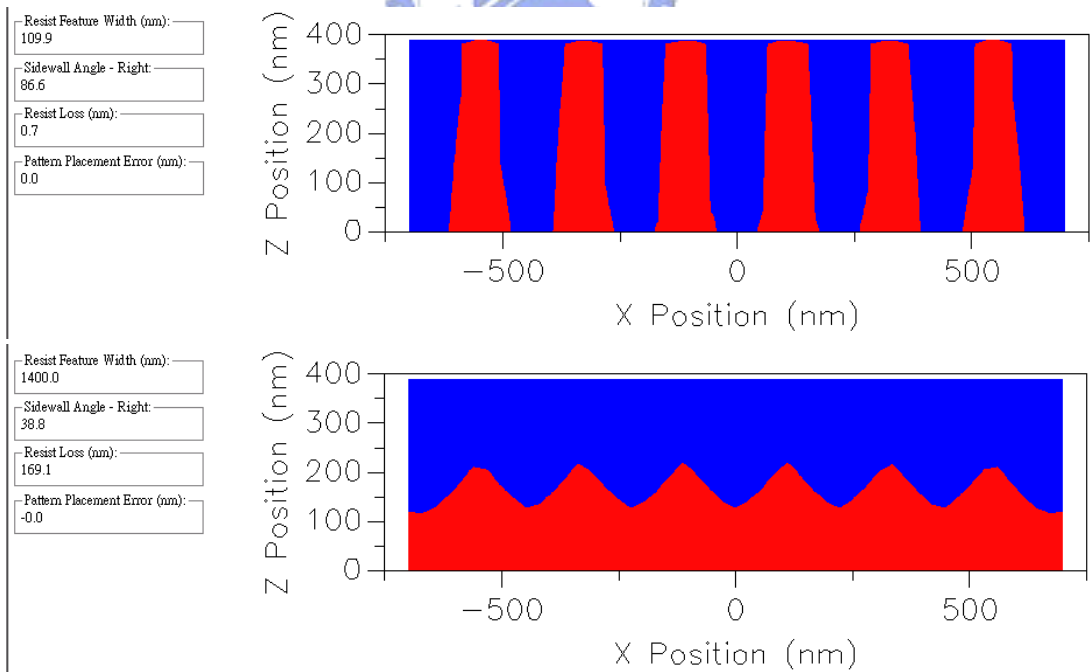


圖 4-31 二孔垂直(上)與平行位向(下)對 110nm 密集線隙之阻劑輪廓
($T=10\%$, 孔距=0.6, 孔徑=0.3, $NA=0.8$, 線隙比=1 : 1)

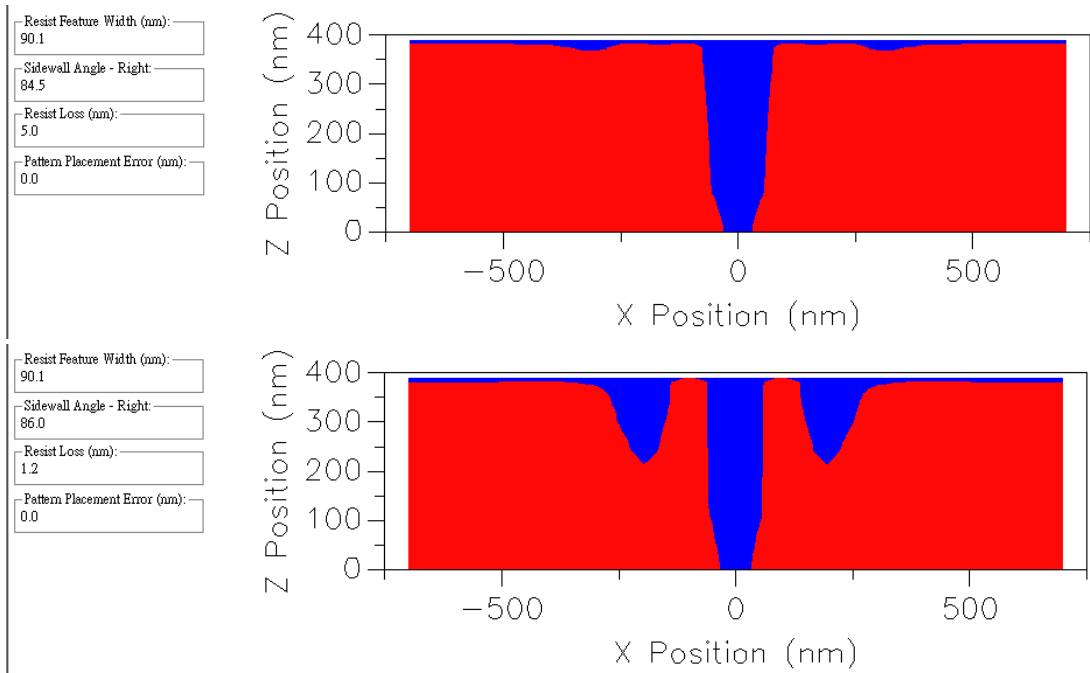


圖 4-32 二孔垂直(上)與平行位向(下)對 90nm 孤立隙之阻劑輪廓
($T=10\%$, 孔距=0.6, 孔徑=0.3, $NA=0.8$, 線寬=2000 nm)

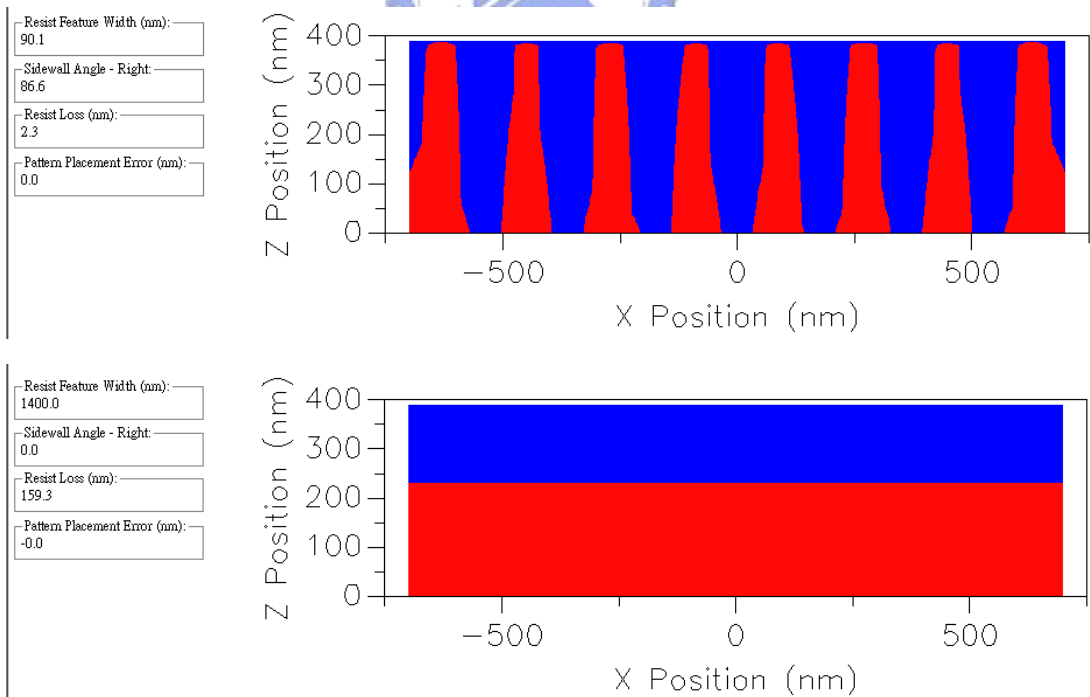
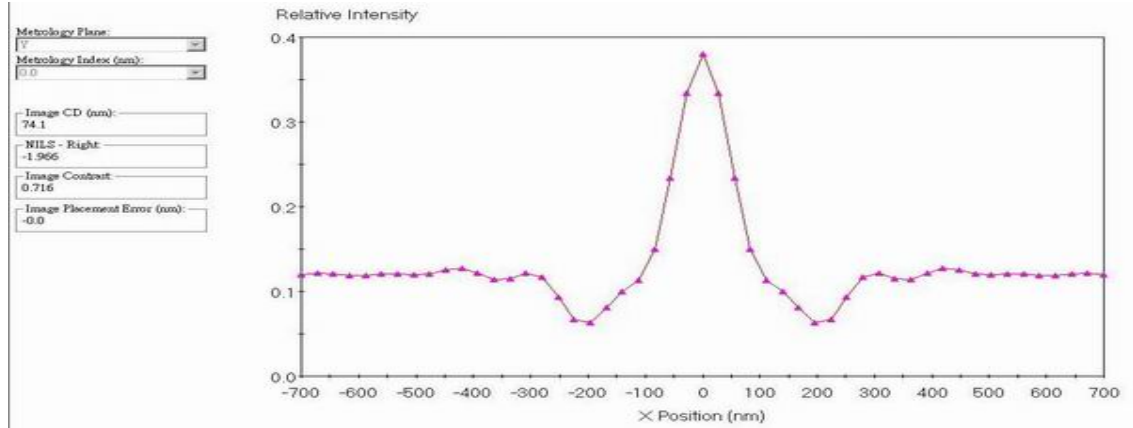
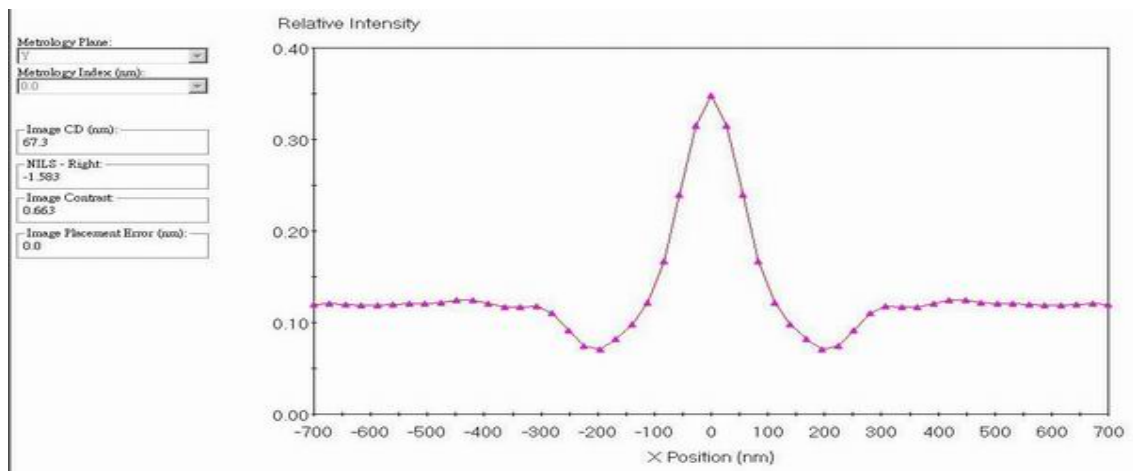


圖 4-33 二孔垂直(上)與平行位向(下)對 90nm 密集線隙之阻劑輪廓
($T=10\%$, 孔距=0.6, 孔徑=0.3, $NA=0.8$, 線隙比=1 : 1)

(A)



(B)



(C)

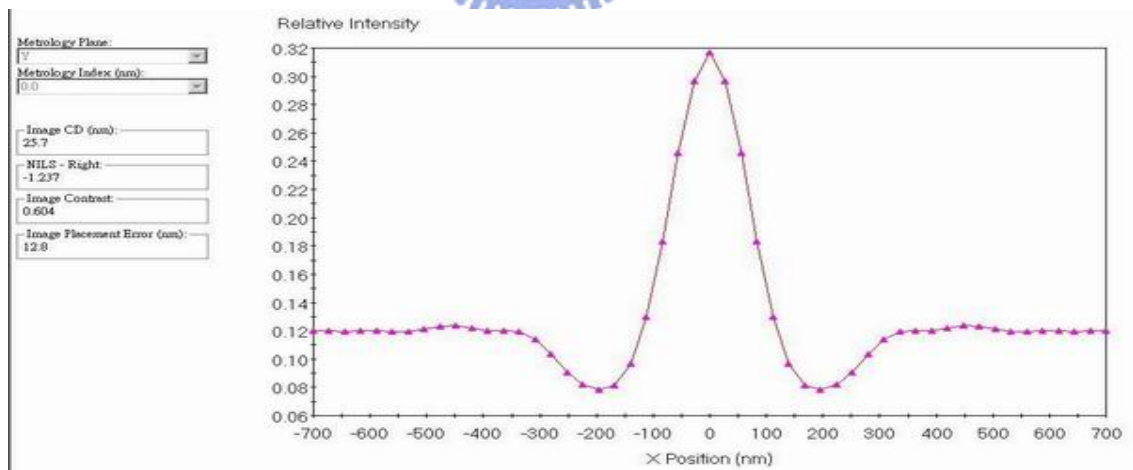


圖 4-34 各種偏振光搭配二孔垂直位向之空間影像：

(A) s 偏振光；(B) 未偏振光；(C) p 偏振光

(T=10% ， 孔距=0.6 ， 孔徑=0.3 ， NA=0.8 ， 隙/線寬=110/2000 nm)

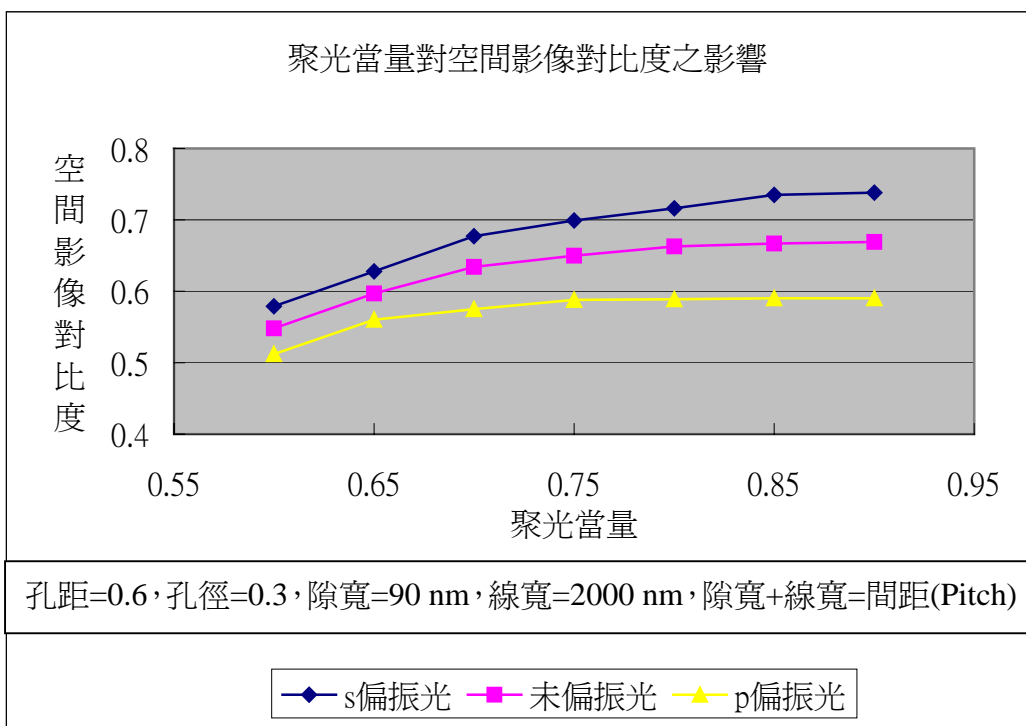


圖 4-35 聚光當量與偏振光種類對空間影像之影響

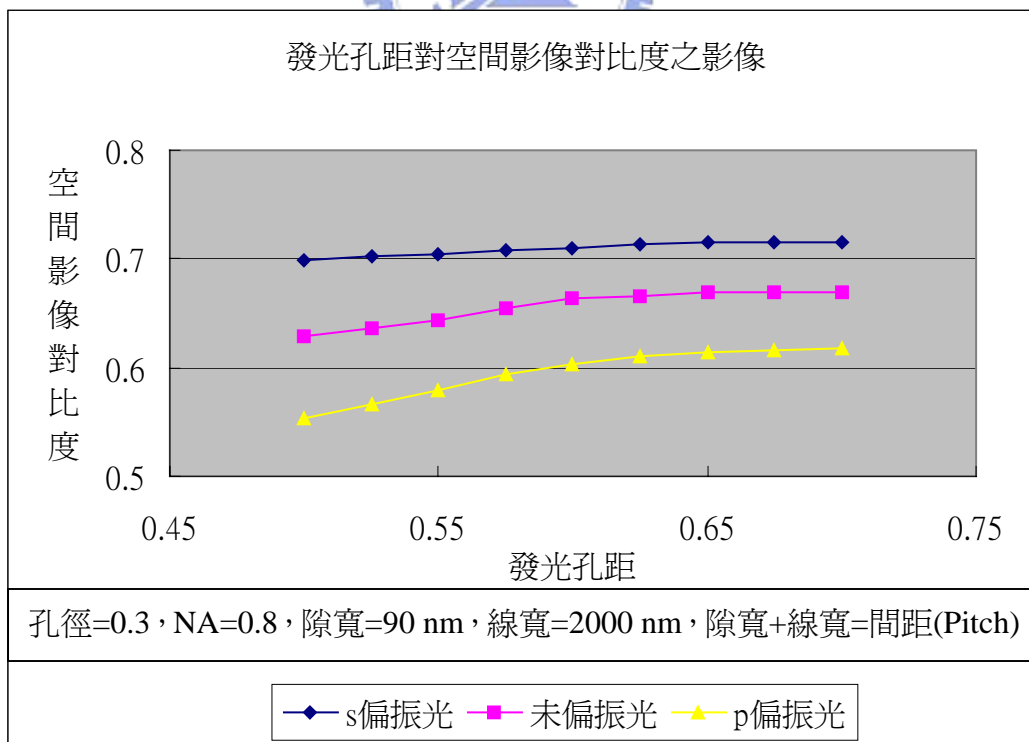


圖 4-36 發光孔距與偏振光種類對空間影像之影響

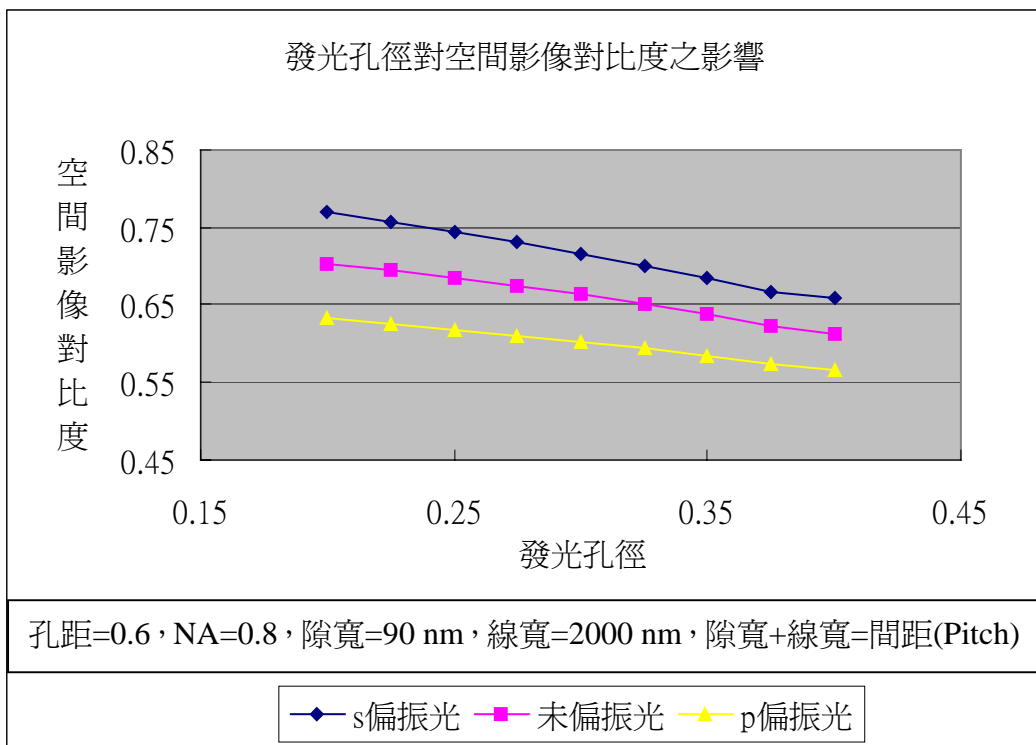


圖 4-37 發光孔徑與偏振光種類對空間影像之影響

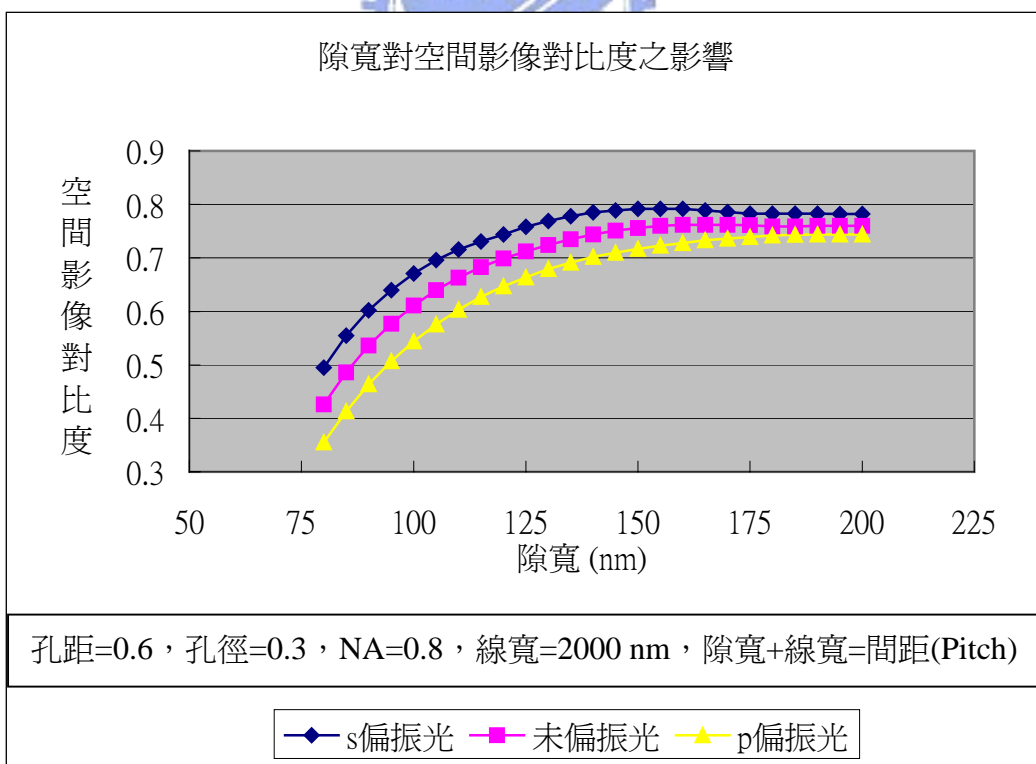
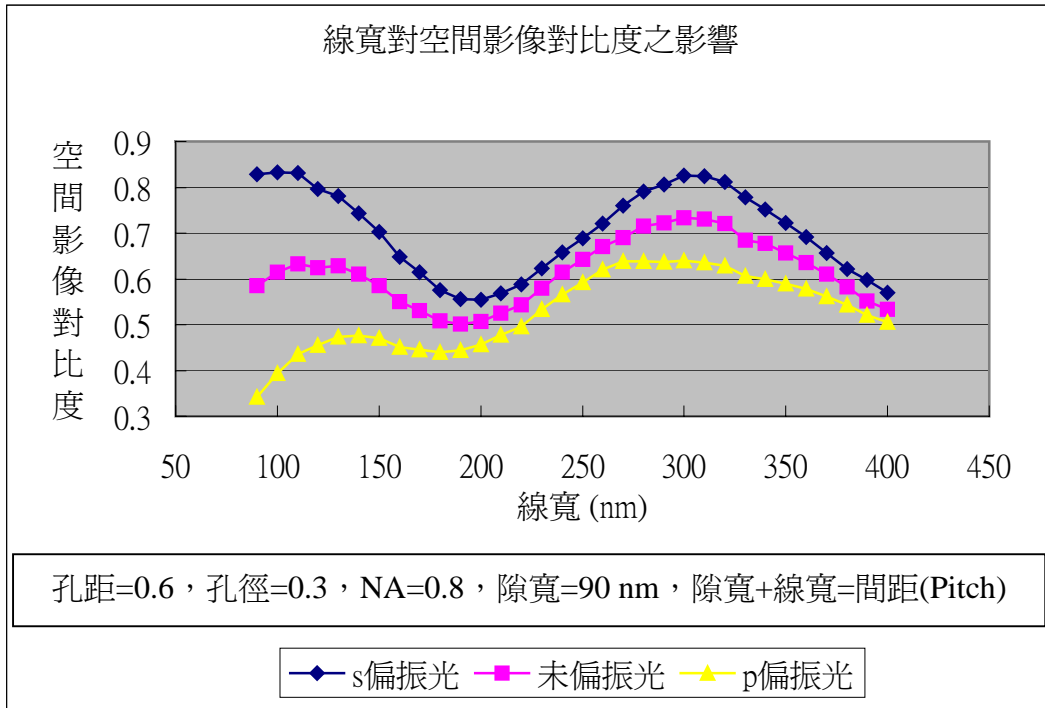


圖 4-38 隙寬與偏振光種類對空間影像之影響

(A)



(B)

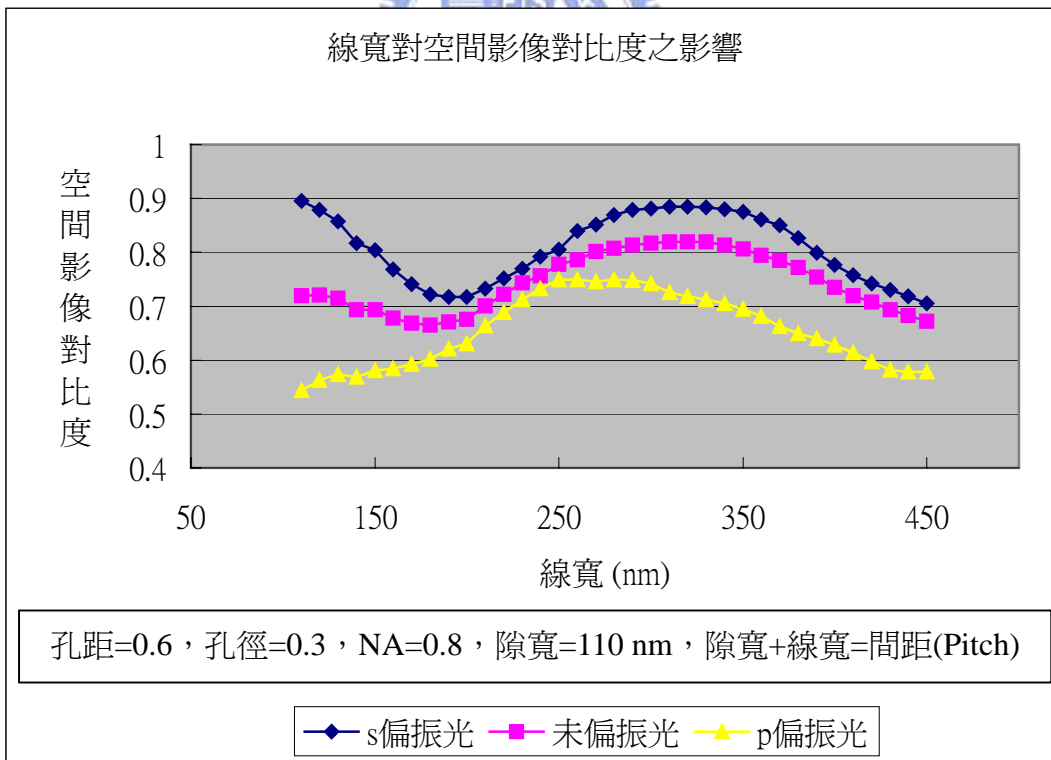


圖 4-39 線寬與偏振光種類對空間影像之影響：

(A) 隙寬 = 90 nm；(B) 隙寬 = 110 nm

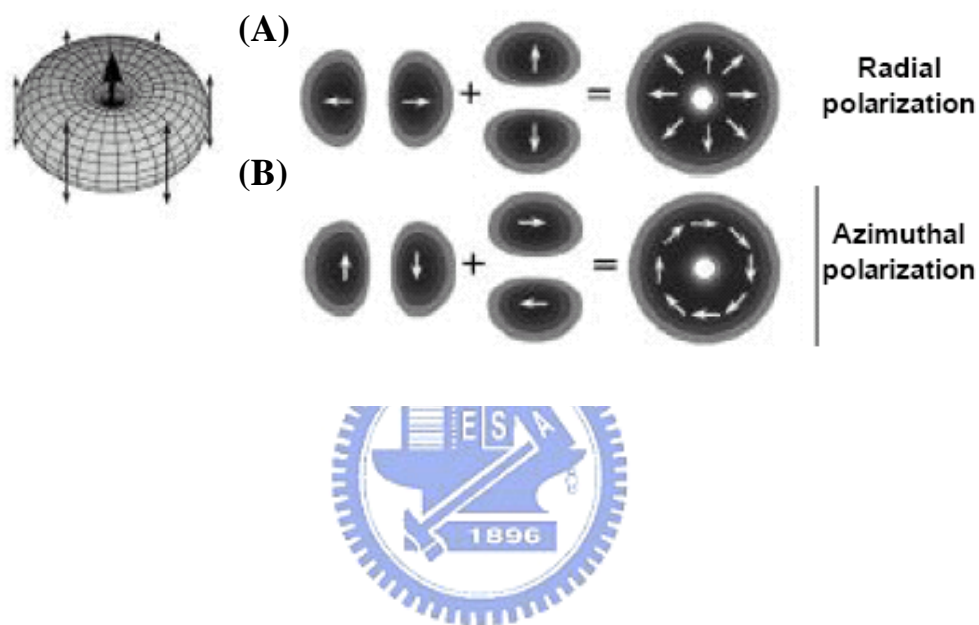


圖 4-40 入射面合向量與其對應之 s 電向量俯視圖：

(A) 入射面；(B) s 電向量