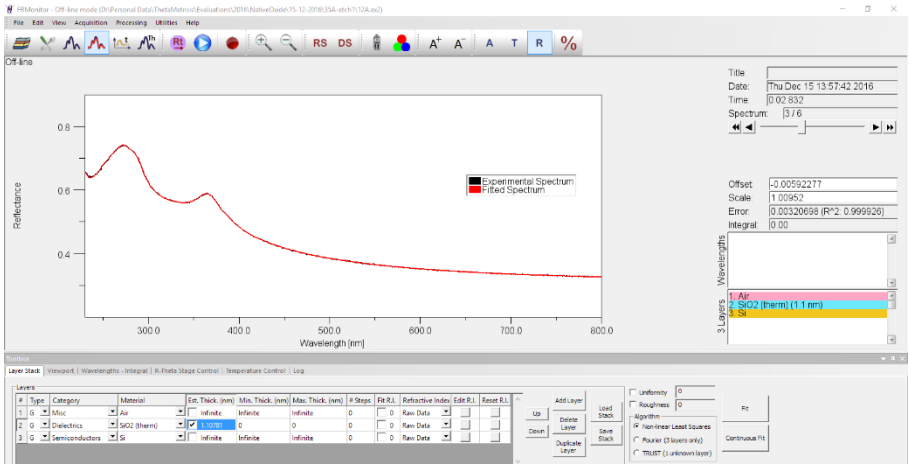
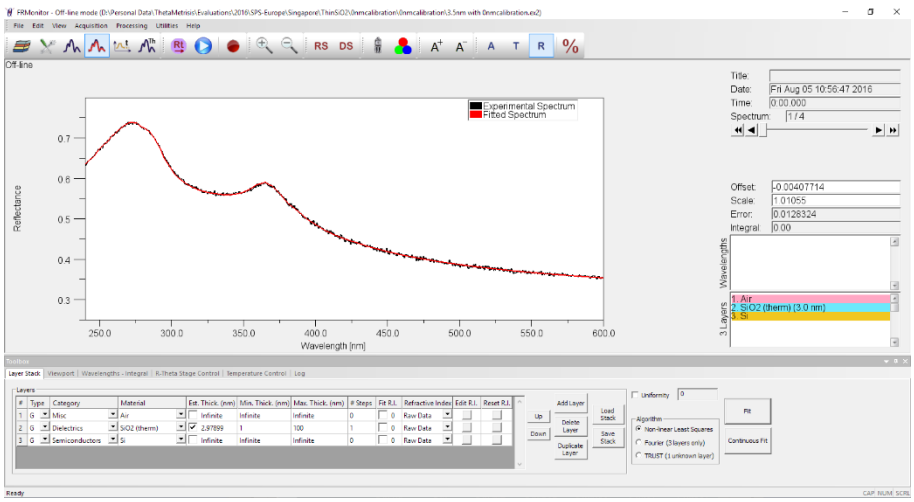
MEASUREMENT OF THE THICKNESS OF THIN & THICK SUPPORTED FILMS

With FR-tools, the thickness of thin & thick, single layer & multi-layer, supported & free-standing, transparent & semi-transparent, uniform & non-uniform films is measured in the 1nm to 1000μm range depending on the actual FR-tool configuration. For the measurement of film thickness in the lower part of the thickness range an FR-Basic tool with spectrometer tuned to operate in UV/VIS is employed. *In certain cases, when an ultra-thin layer is deposited on a transparent layer of known thickness, then the thickness of this ultra-thin layer can be measured even if it is <1nm thick.* In the following screen-shots, representative measurements of single films applied on Si wafer (semi-reflective) and glass (transparent) substrates are illustrated for film thickness in the range of 3 nm to 200 μm.

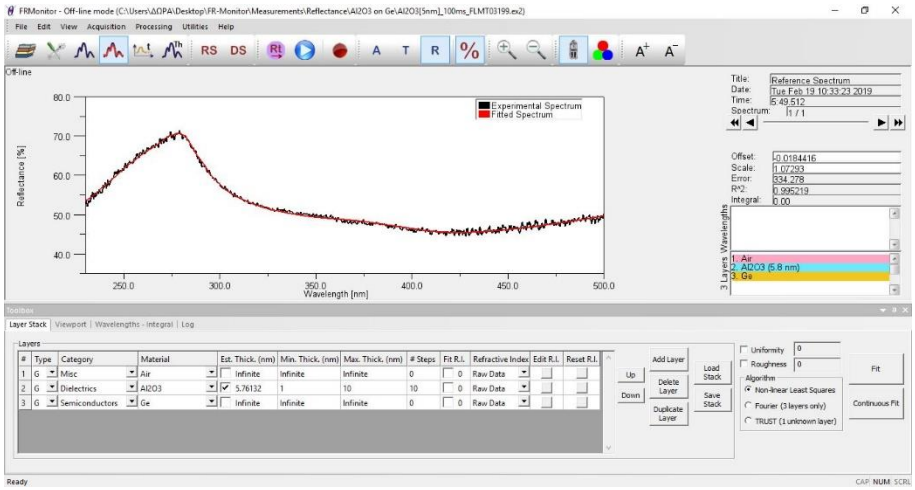
Ultra-Thin Films (<10nm)



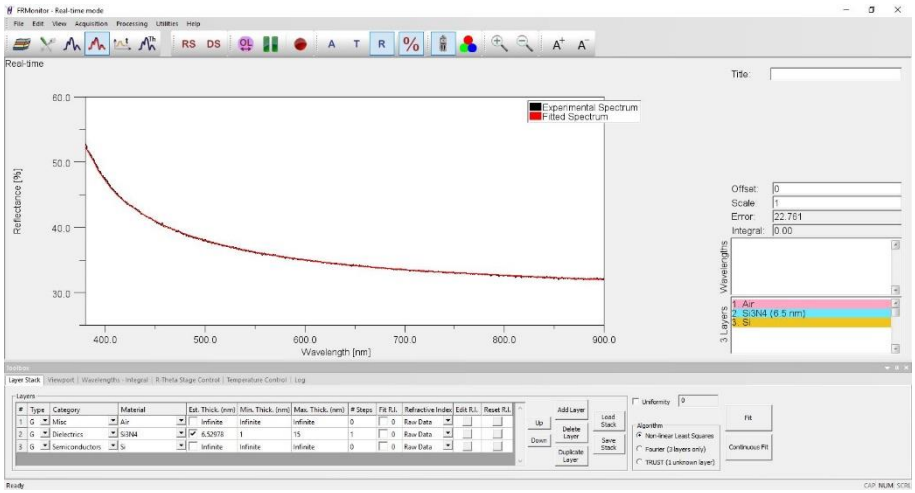
SiO_2 on Si wafer. SiO_2 film thickness: 1.1 nm.



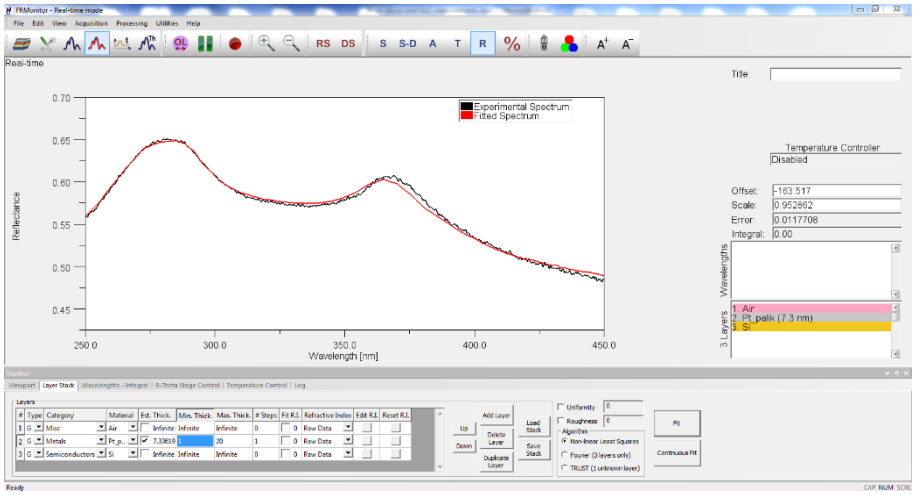
SiO_2 on Si wafer. SiO_2 film thickness: 3.0 nm.



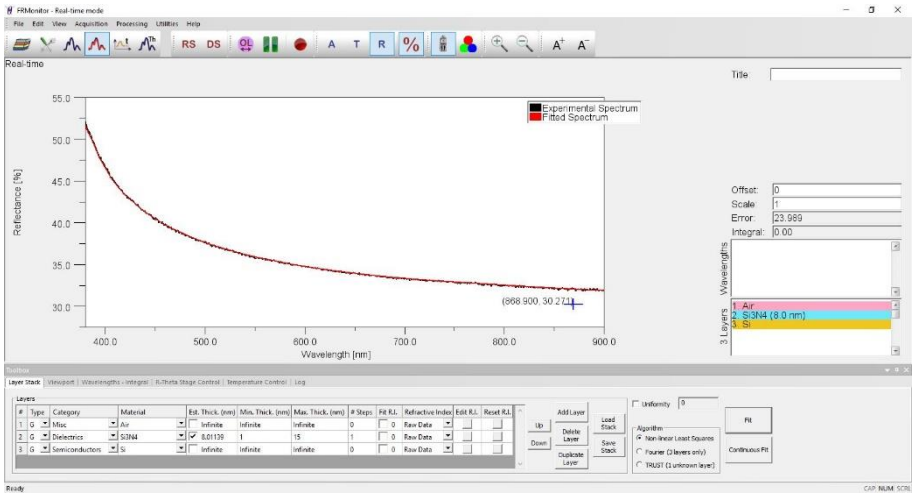
Al_2O_3 on Ge wafer. Al_2O_3 film thickness: 5.8 nm.



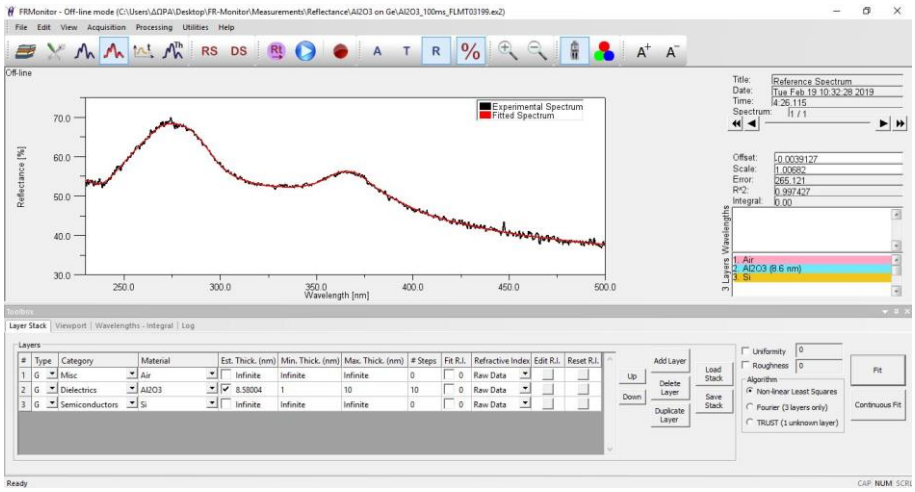
Si_3N_4 on Si wafer. Si_3N_4 film thickness: 6.5 nm.



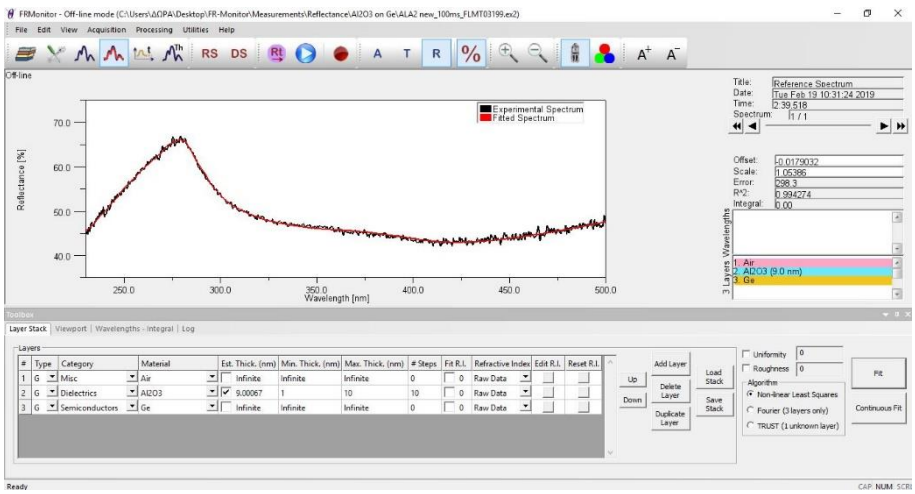
Pt on Si wafer. Pt film thickness: 7.3 nm.



Si_3N_4 on Si wafer. Si_3N_4 film thickness: 8.0 nm.

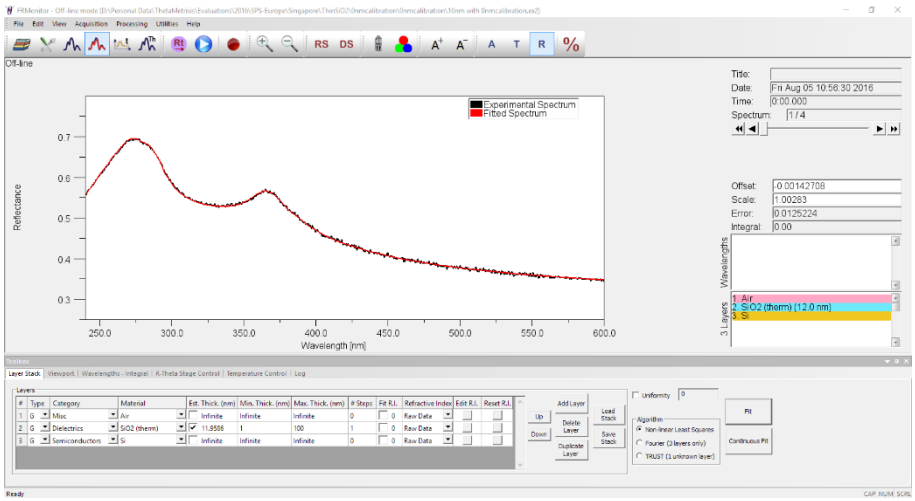


Al_2O_3 on Si wafer. Al_2O_3 film thickness: 8.5 nm.

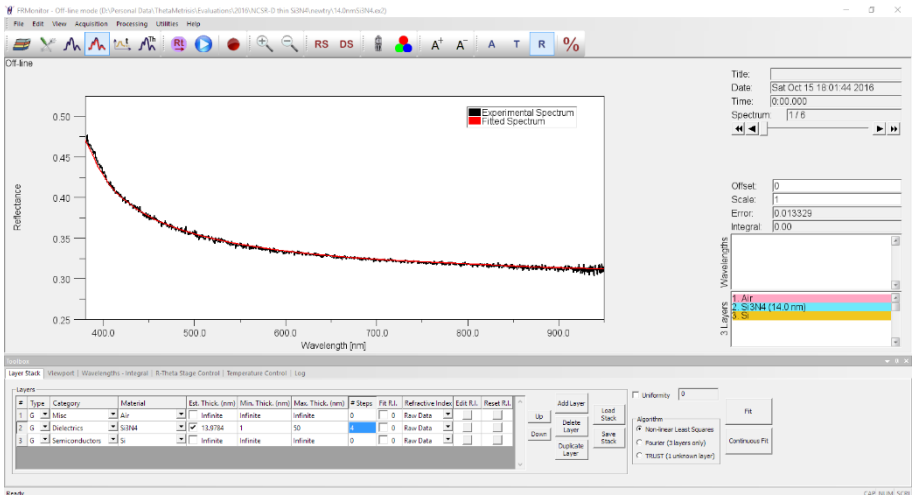


Al_2O_3 on Ge wafer. Al_2O_3 film thickness: 9.0 nm.

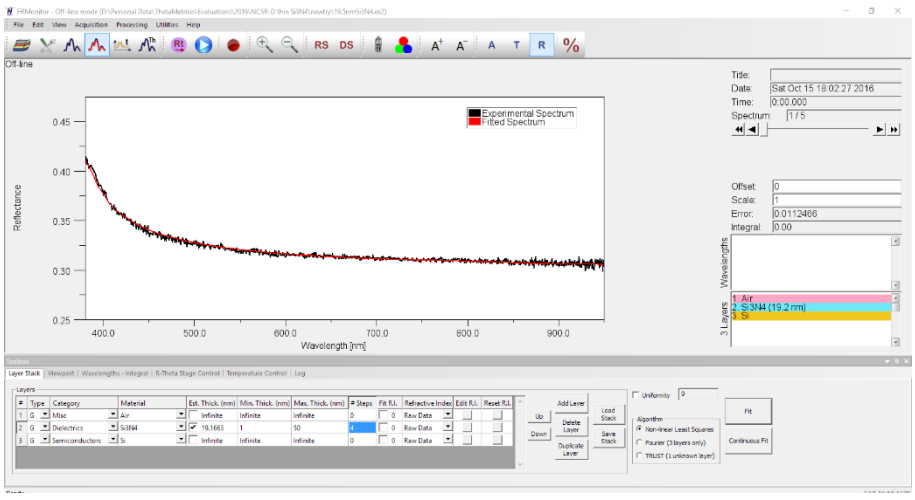
Thin films (10nm- 100nm)



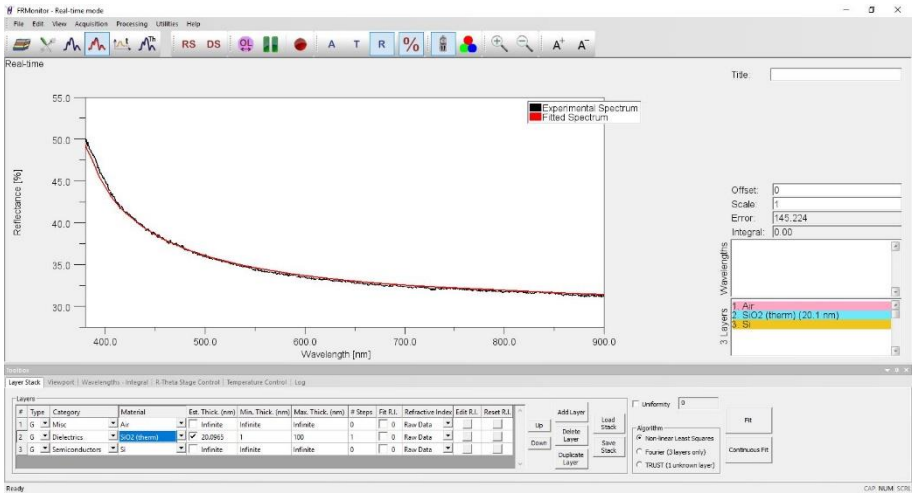
SiO_2 on Si wafer. SiO_2 film thickness: 12.0 nm.



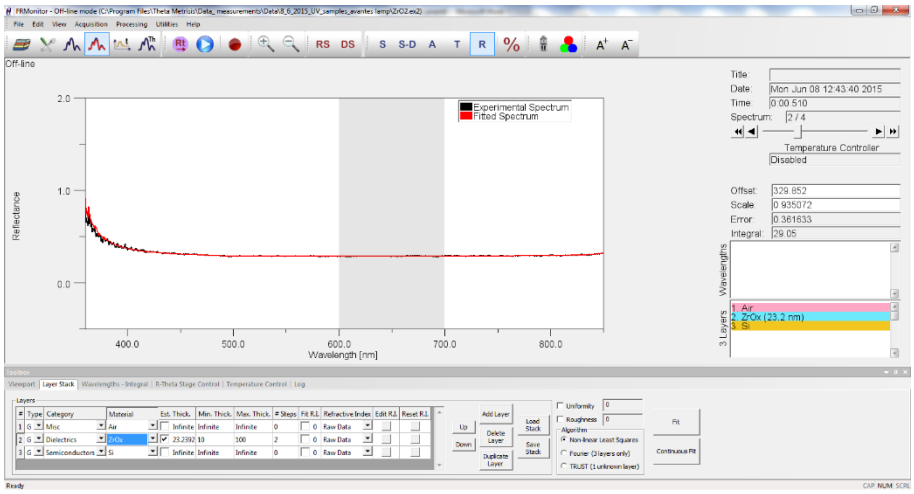
Si_3N_4 on Si wafer. Si_3N_4 film thickness: 14.0 nm.



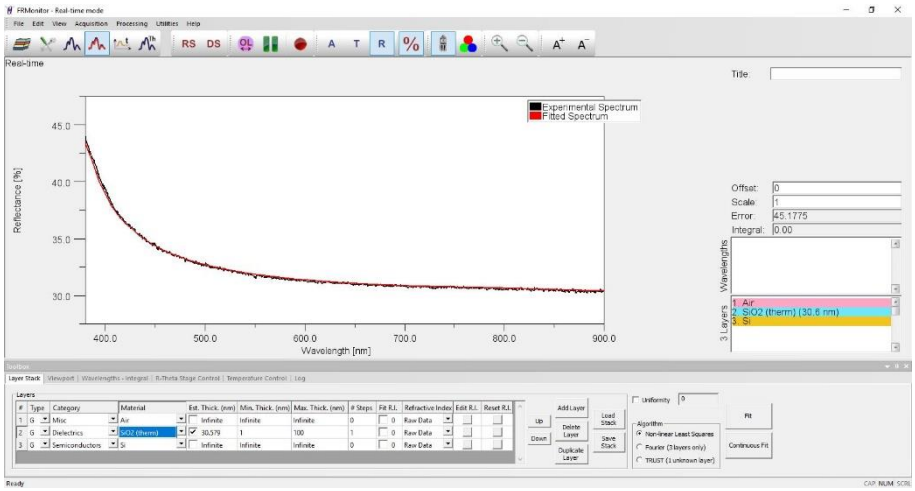
Si_3N_4 on Si wafer. Si_3N_4 film thickness: 19.1 nm.



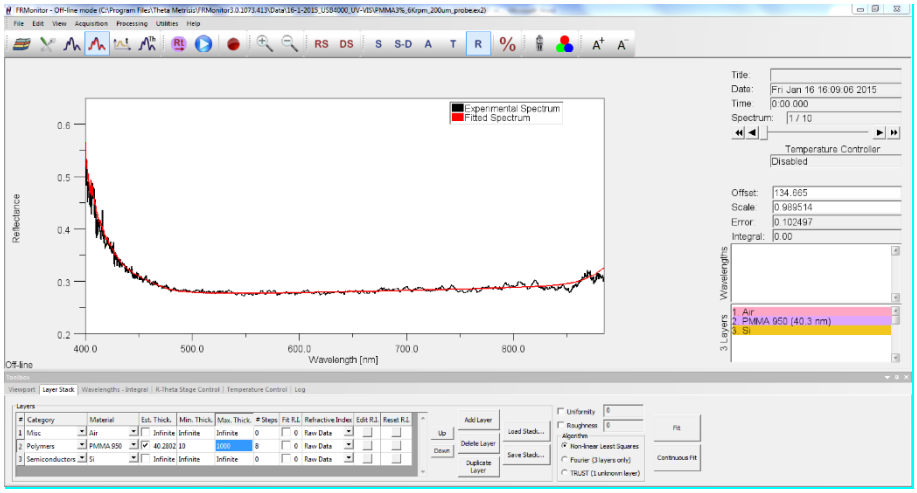
SiO_2 on Si wafer. SiO_2 film thickness: 20.1 nm.



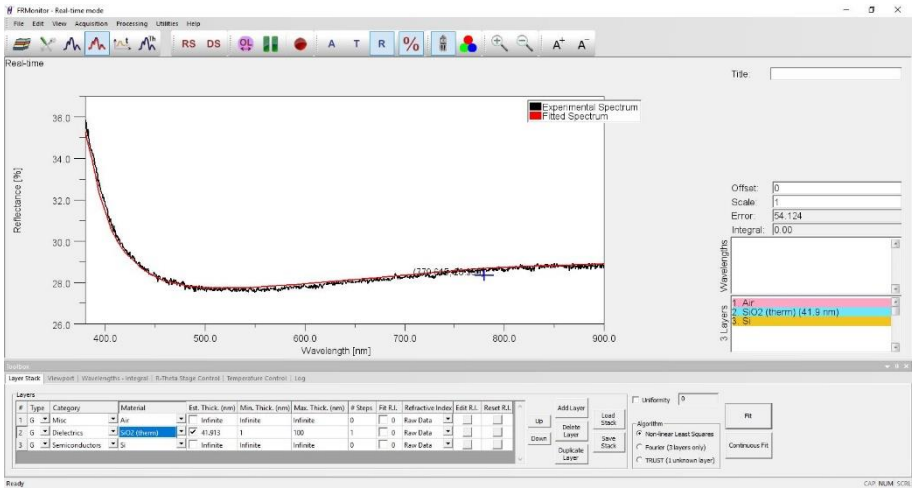
ZrO_2 on Si wafer. ZrO_2 film thickness: 23.2 nm.



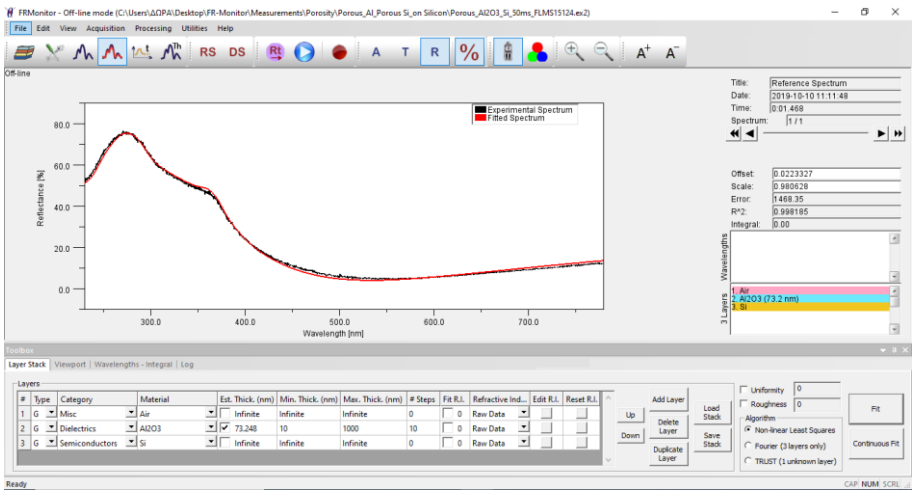
SiO_2 on Si wafer. SiO_2 film thickness: 30.6 nm.



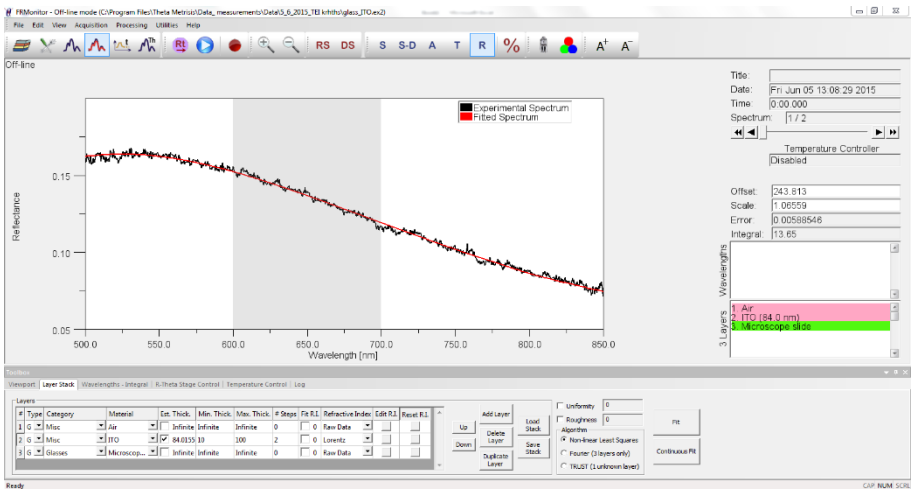
PMMA on Si wafer. PMMA film thickness: 40.3 nm.



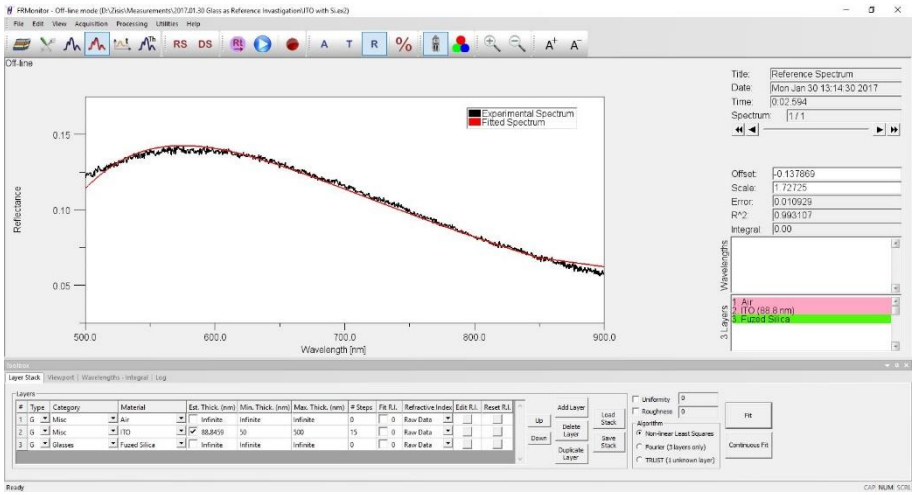
SiO_2 on Si wafer. SiO_2 film thickness: 41.9 nm.



Porous Al_2O_3 on Si wafer. Porous Al_2O_3 film thickness: 73.2nm

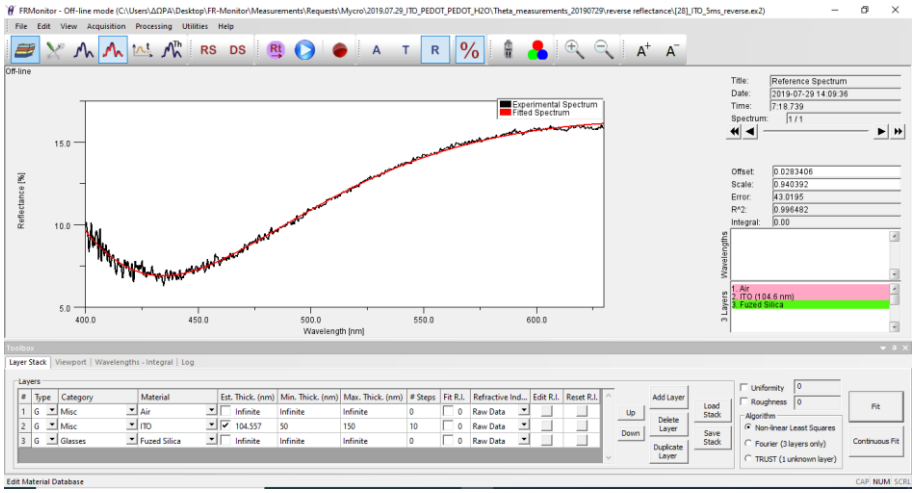


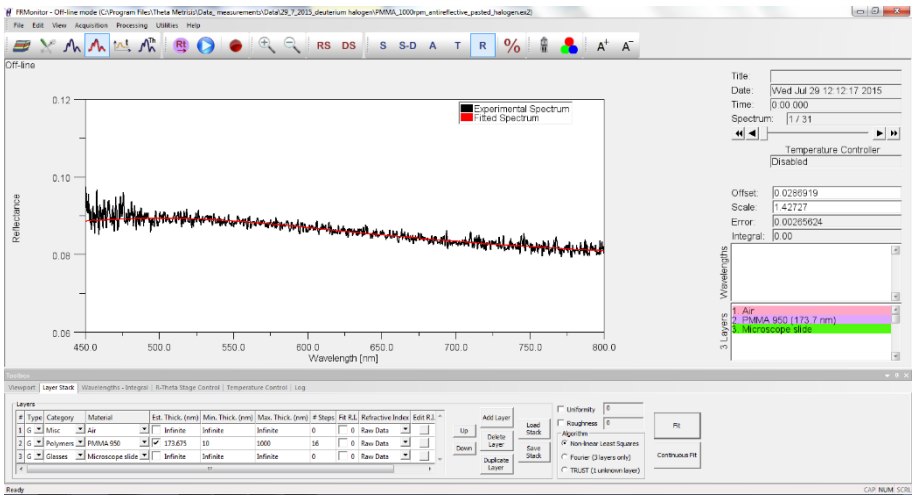
TiO_2 on microscope glass. TiO_2 film thickness: 84.0 nm



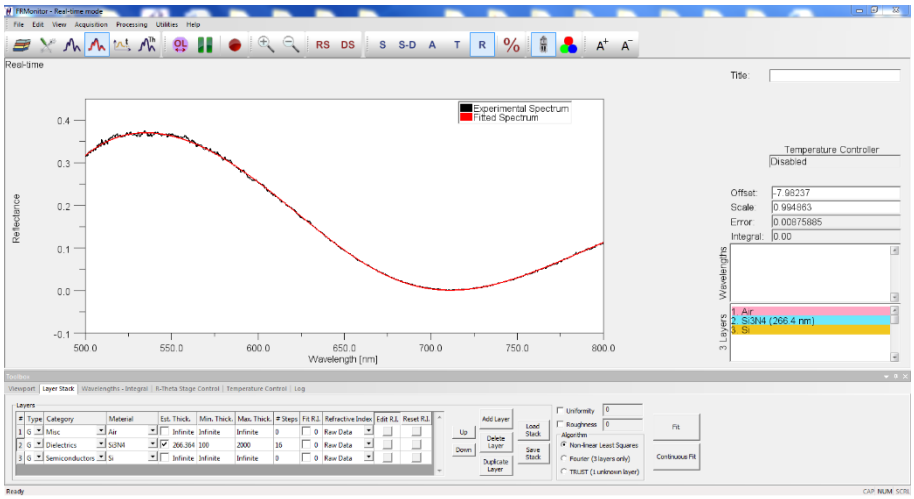
ITO on Fused Silica substrate. ITO film thickness: 88.8 nm

Conventional films (100nm-1000nm)

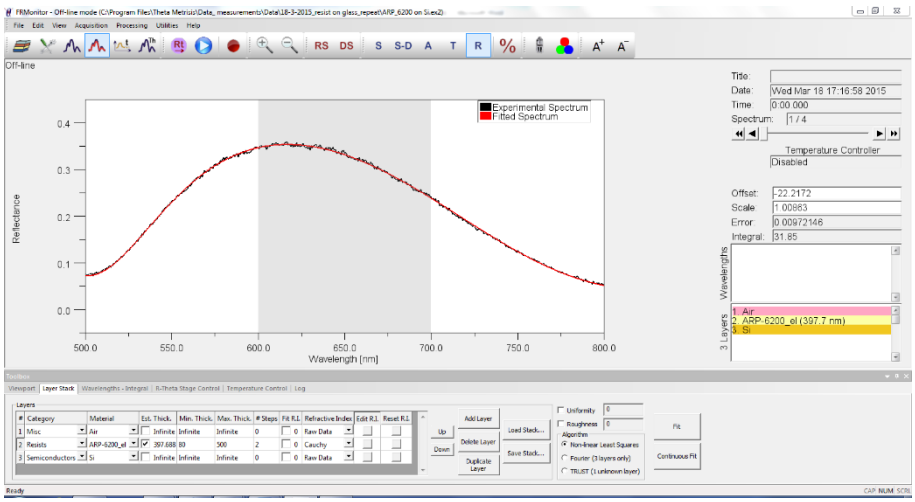




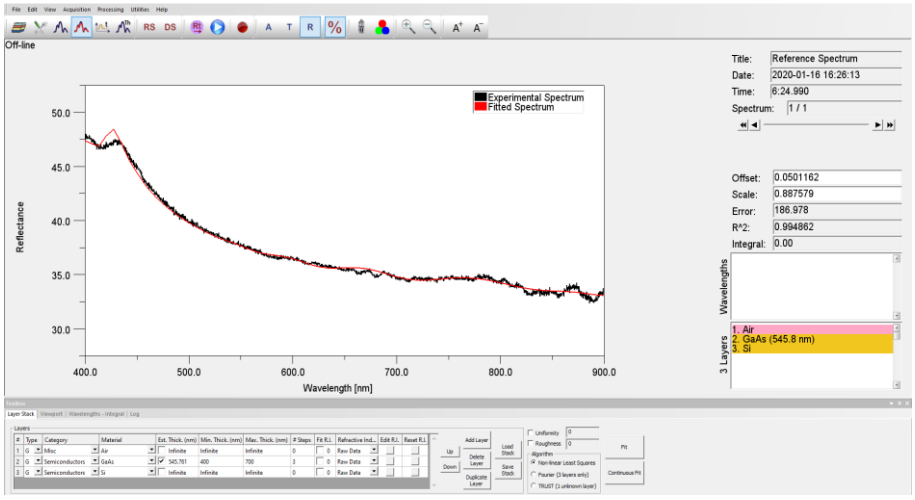
PMMA -1000 rpm spin coating on microscope glass. PMMA film thickness: 173.7 nm



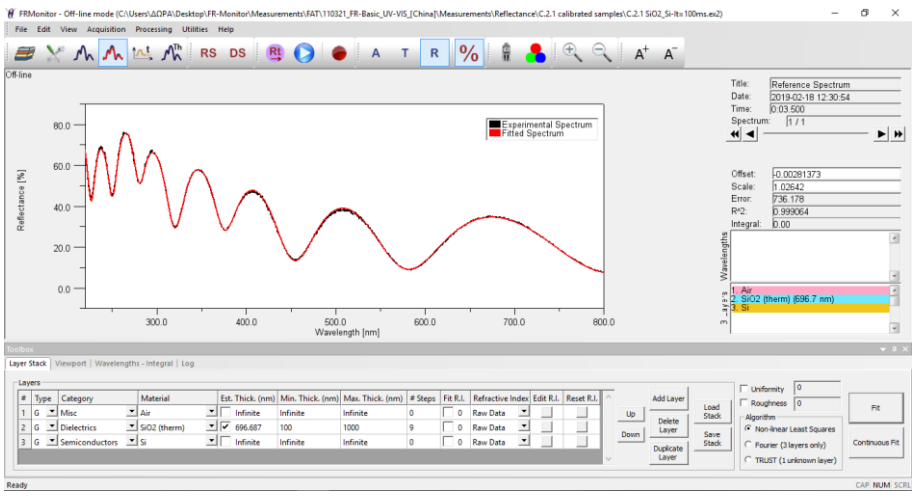
Si_3N_4 on Si wafer. Si_3N_4 film thickness: 266.4 nm



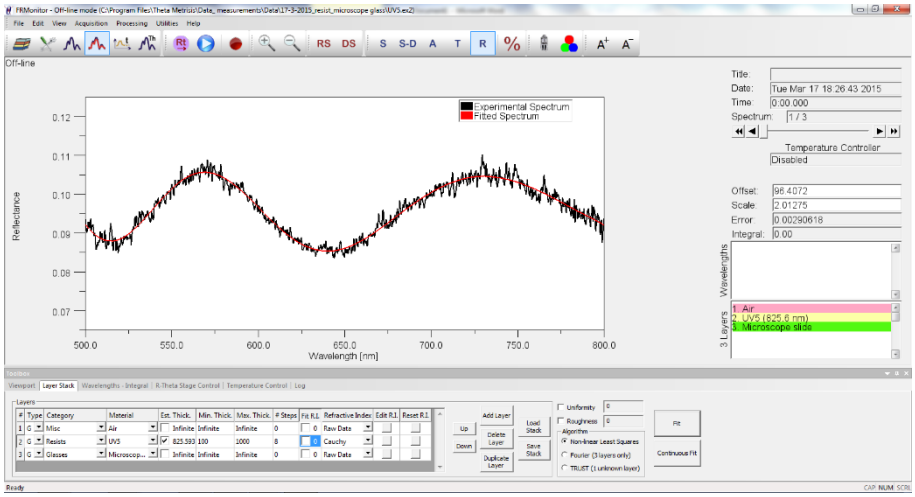
AR-P 6200 on Si wafer. AR-P 6200 film thickness: 397.7 nm



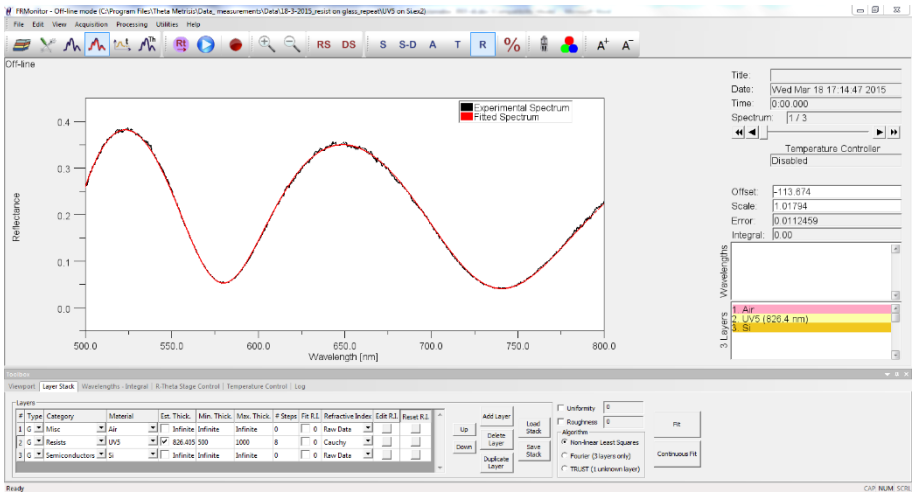
GaAs on Si wafer. GaAs film thickness: 545.8nm



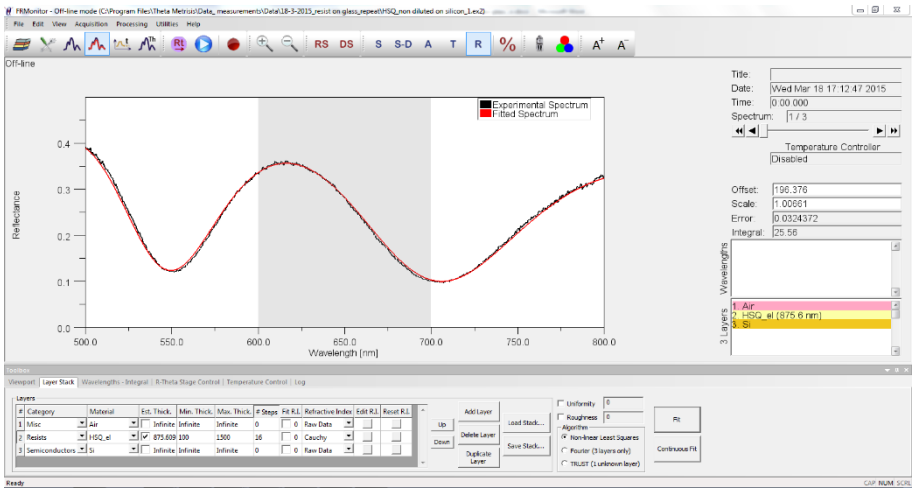
SiO_2 on Si wafer. SiO_2 film thickness: 696.7 nm



UV5 resist on microscope glass wafer. UV5 film thickness: 825.6 nm

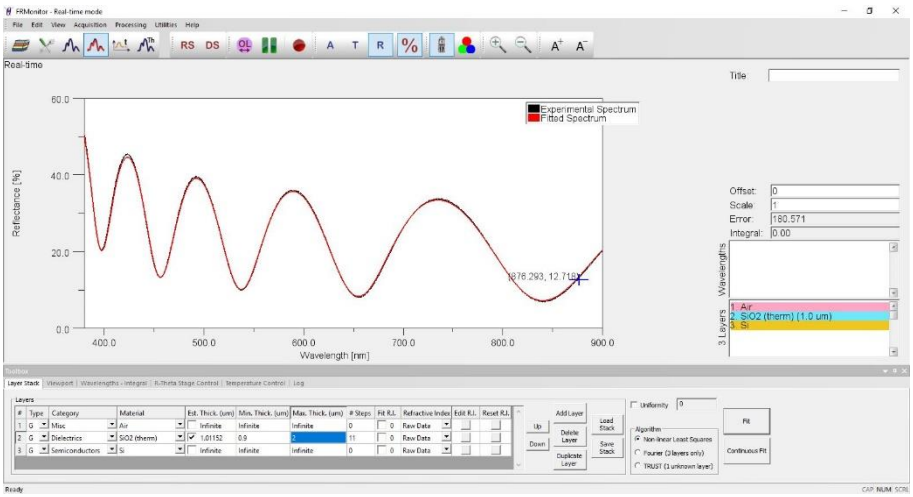


UV5 on Si wafer. UV5 film thickness: 826.4 nm

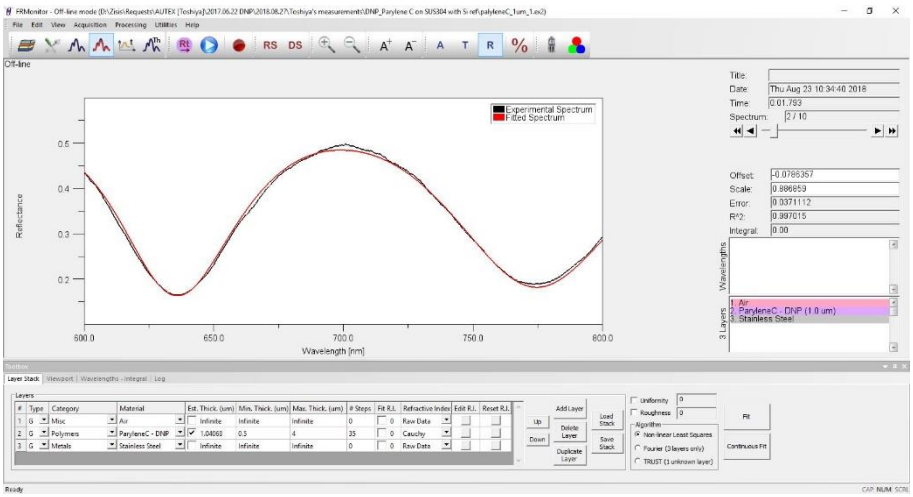


HSQ resist on microscope glass wafer. HSQ film thickness: 875.6 nm

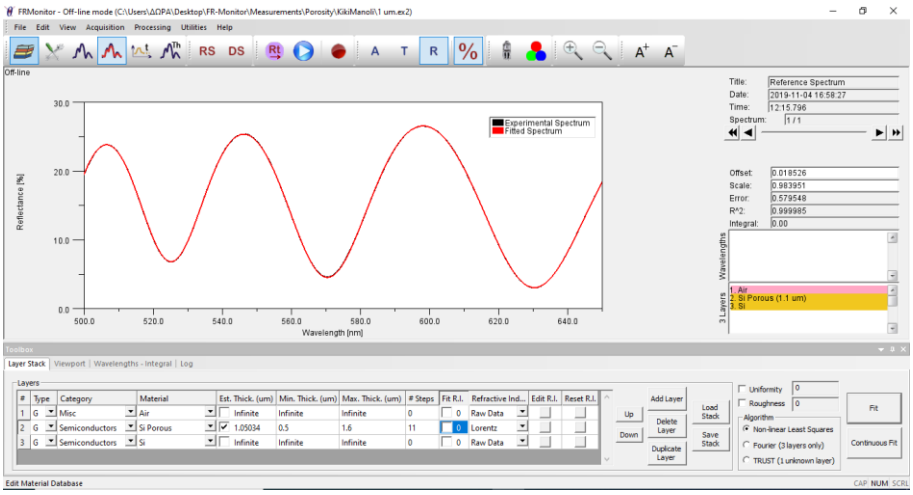
Thick films (1µm-10µm)



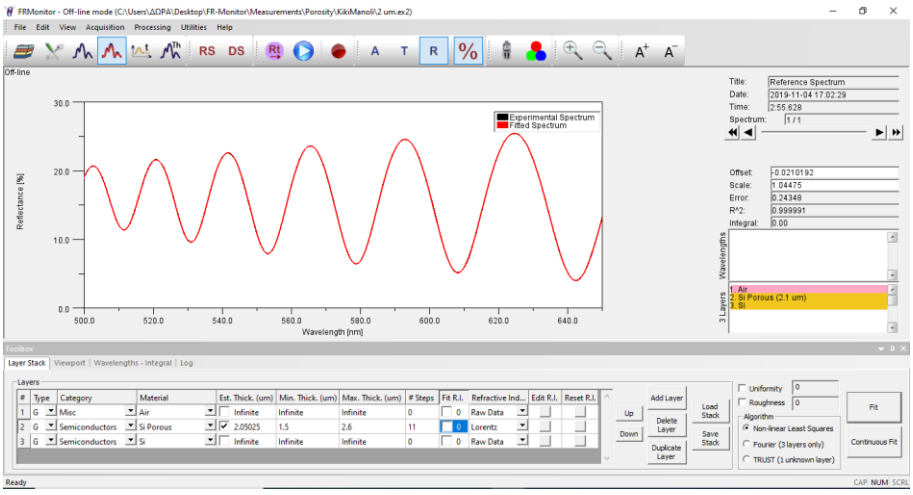
SiO_2 on Si wafer. SiO_2 film thickness: 1.01 µm



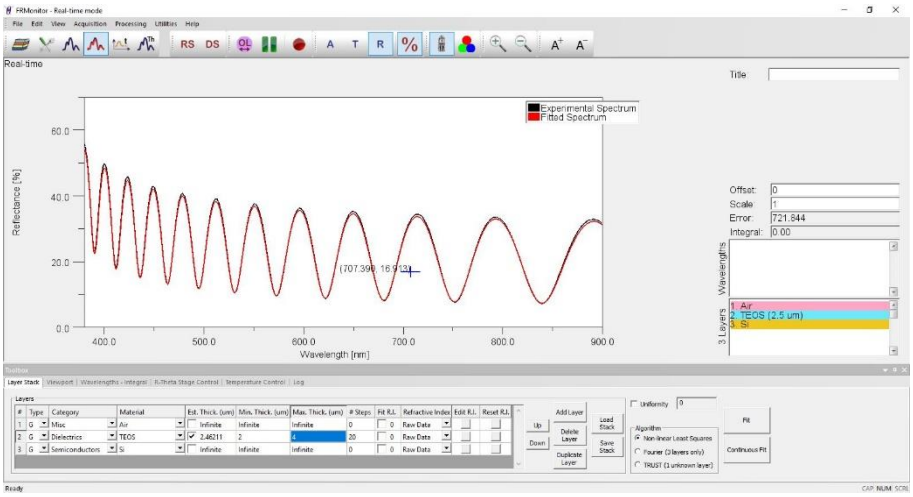
Parylene coating on Stainless Steel. Parylene C film thickness: 1.04 µm



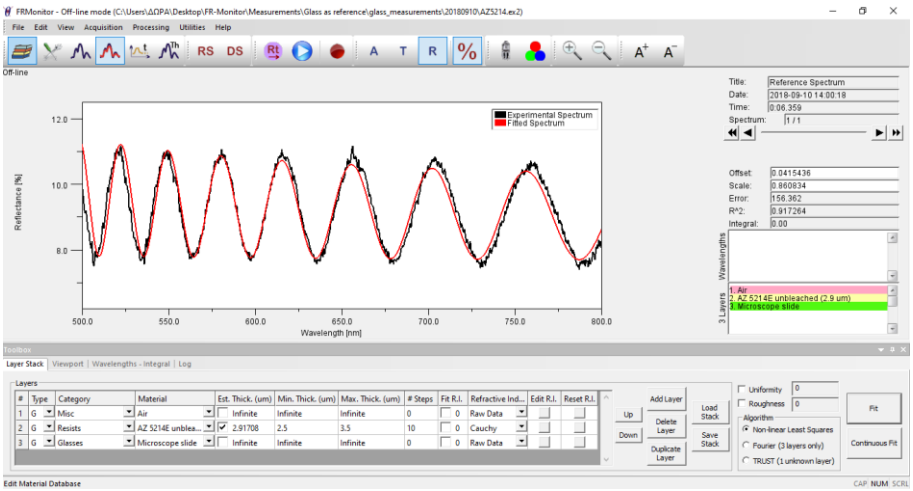
Porous Si on Silicon wafer. Porous Si film thickness: 1.05 µm



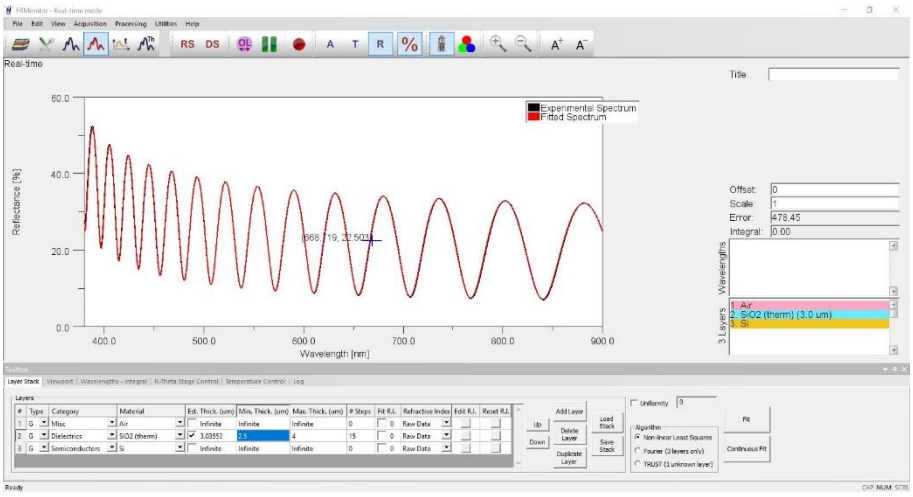
Porous Si on Silicon wafer. Porous Si film thickness: 2.05 µm



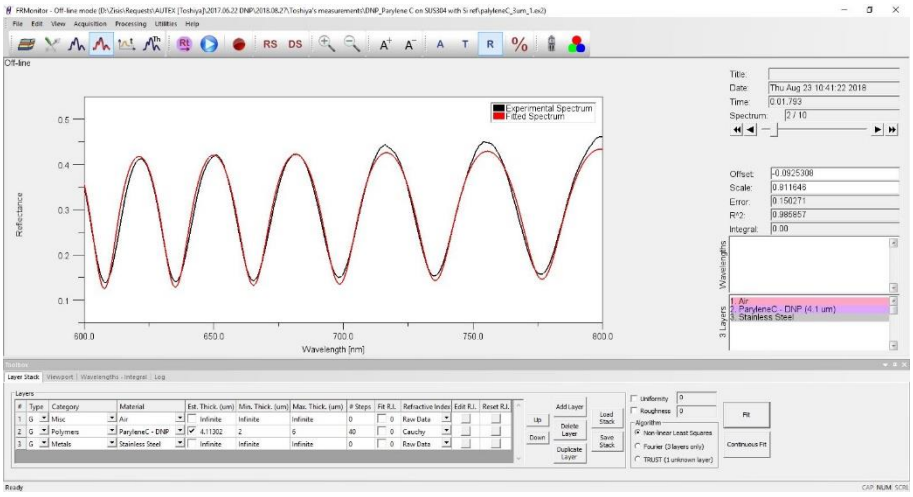
TEOS on Si wafer. TEOS film thickness: 2.46 µm



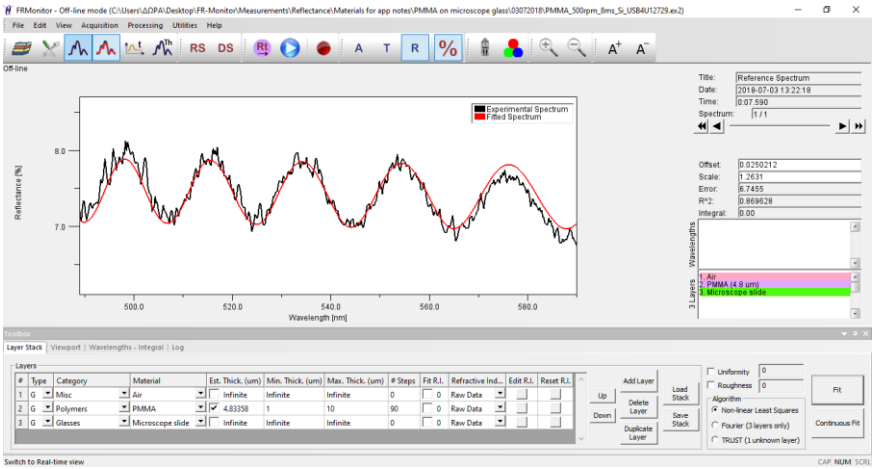
AZ5214 on microscope glass. AZ5214 film thickness: 2.9 µm



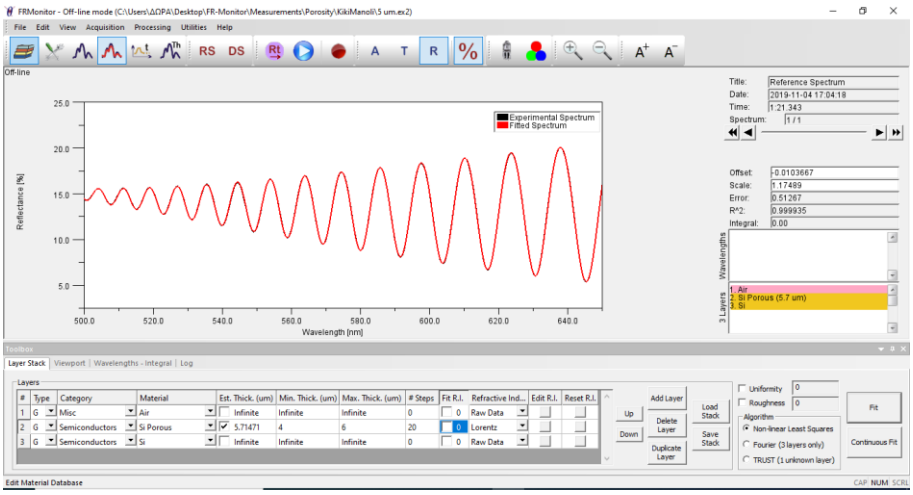
SiO_2 on Si wafer. SiO_2 film thickness: 3.03 µm



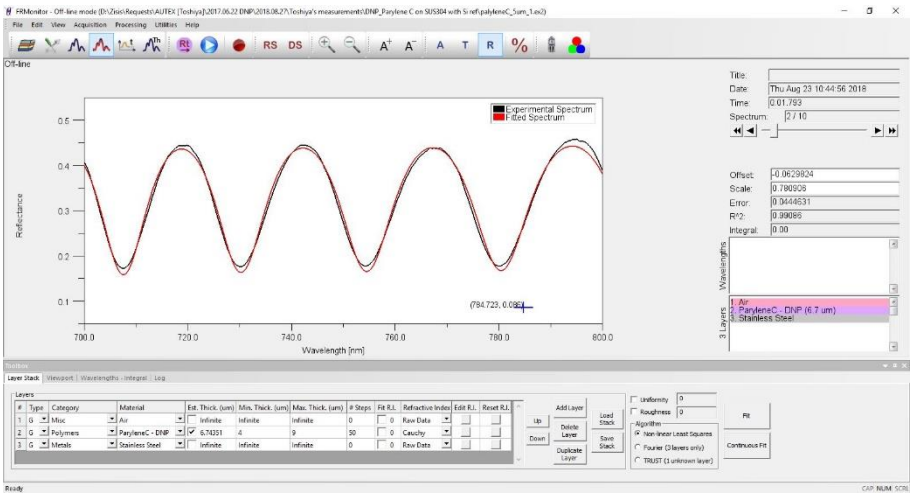
Parylene coating on Stainless Steel. Parylene C thickness: 4.11 µm



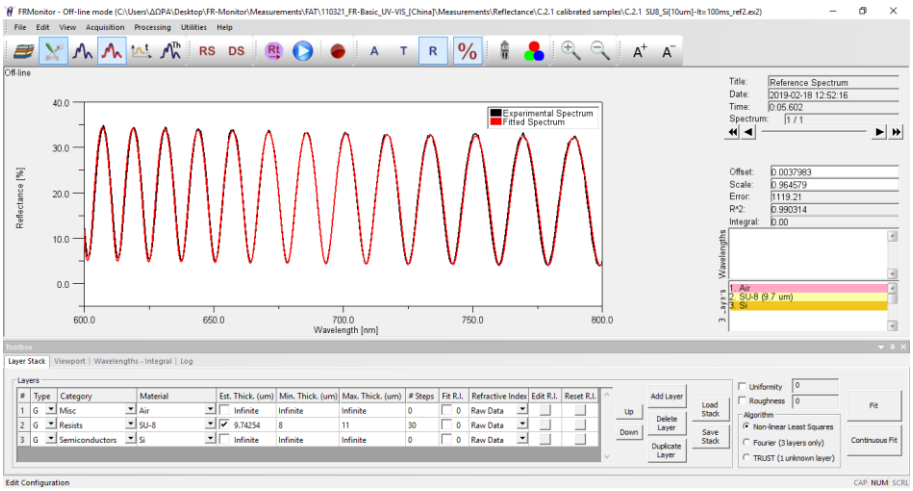
PMMA on microscope glass substrate. PMMA thickness: 4.83 µm



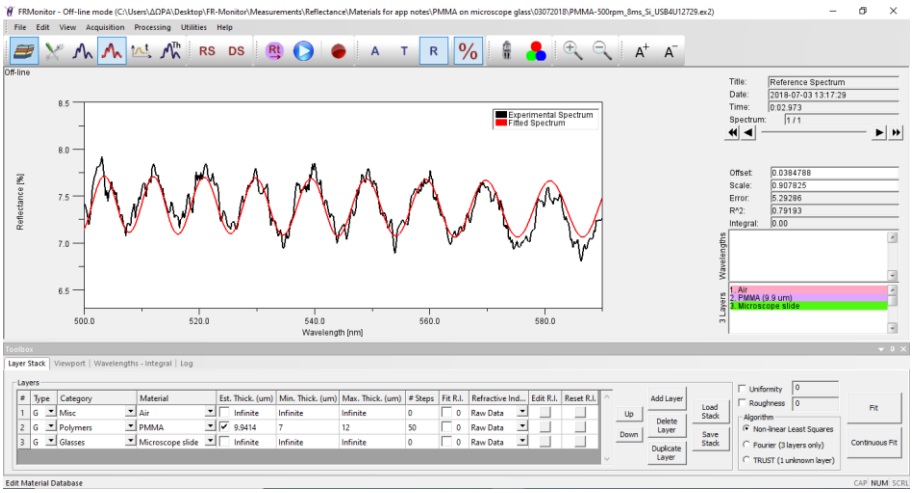
Porous Si on Silicon wafer. Porous Si film thickness: 5.71 µm



Parylene coating on Stainless Steel. Parylene C thickness: 6.74 µm

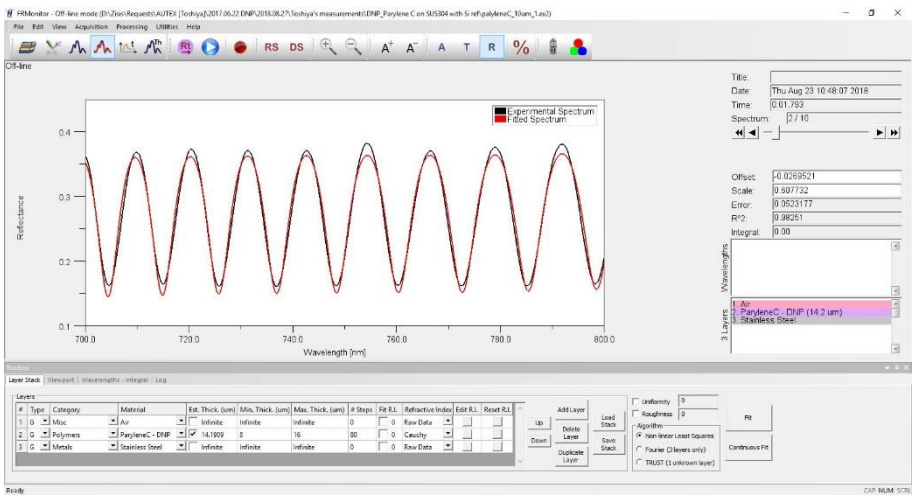


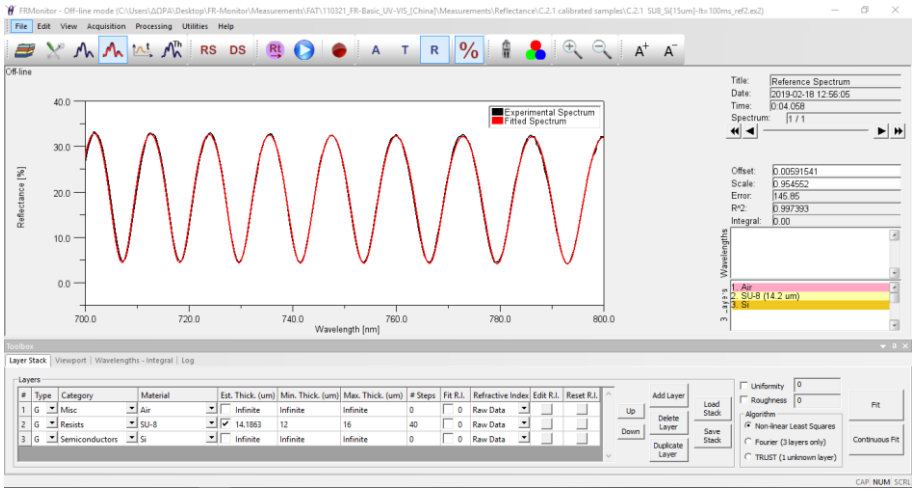
SU-8 on Si wafer. SU-8 film thickness: 9.7 µm

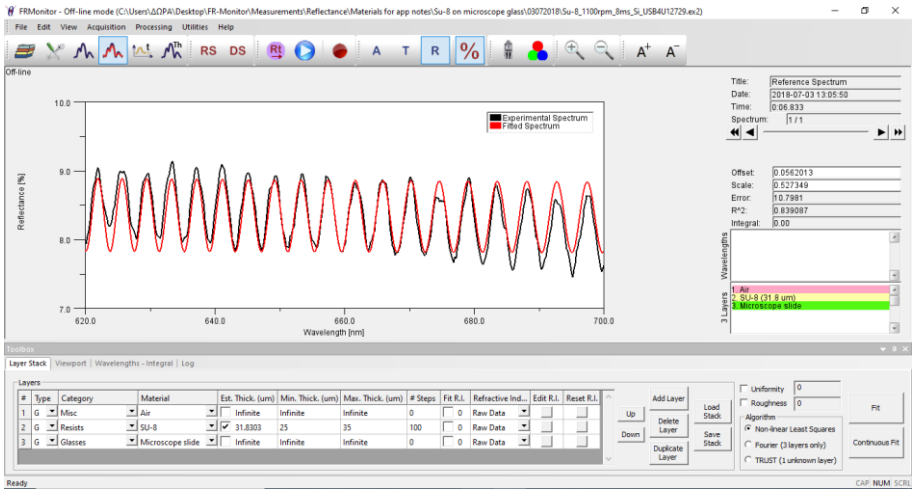


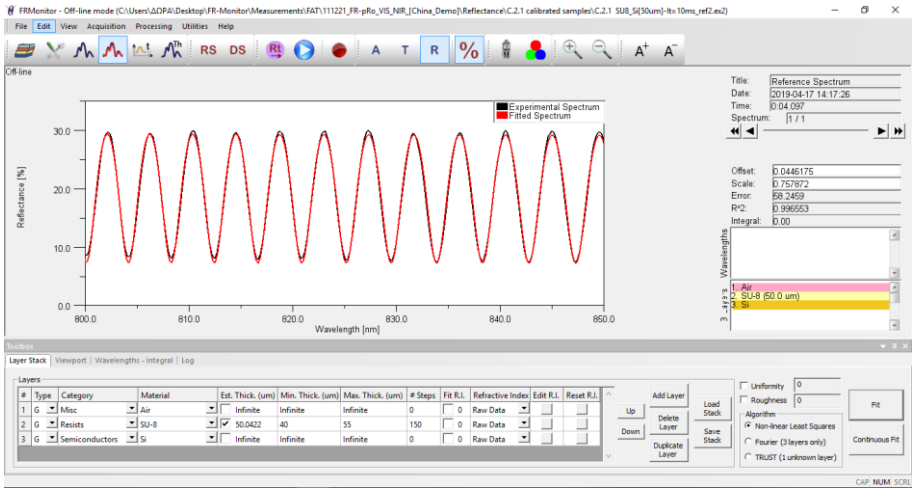
PMMA on microscope glass substrate. PMMA thickness: 9.94 µm

Very Thick films (10µm-100µm)

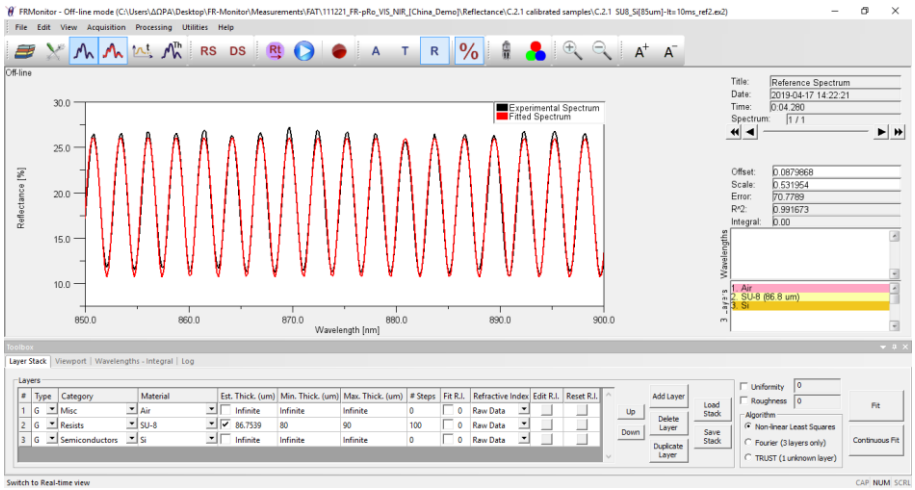






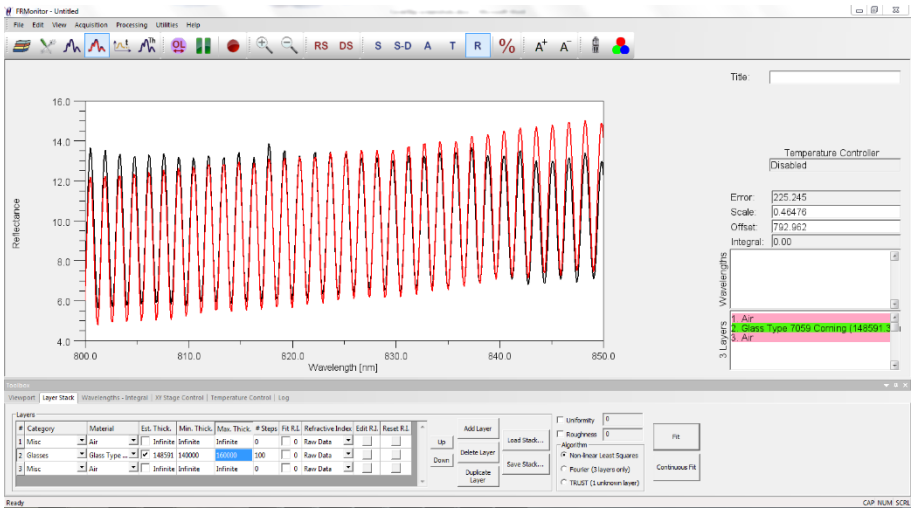


SU-8 on Si wafer. SU-8 film thickness: 50 µm

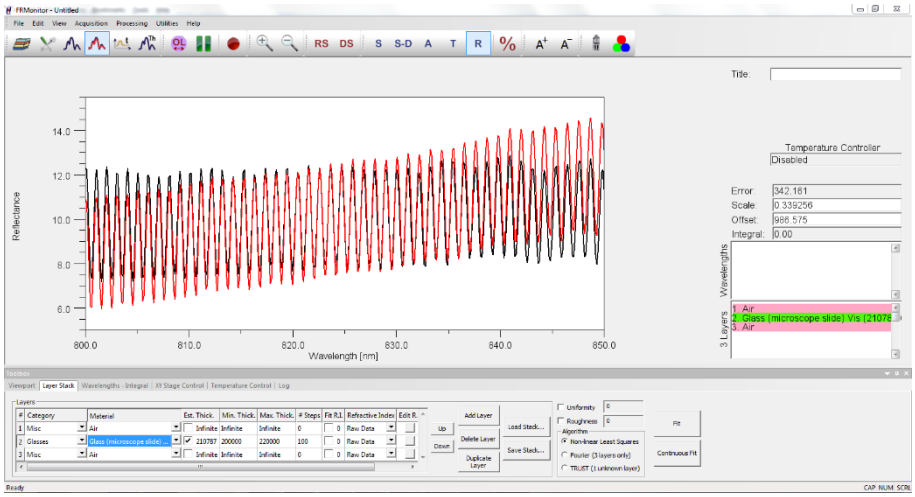


SU-8 on Si wafer. SU-8 film thickness: 86.75 µm

Ultra Thick films (>100µm)



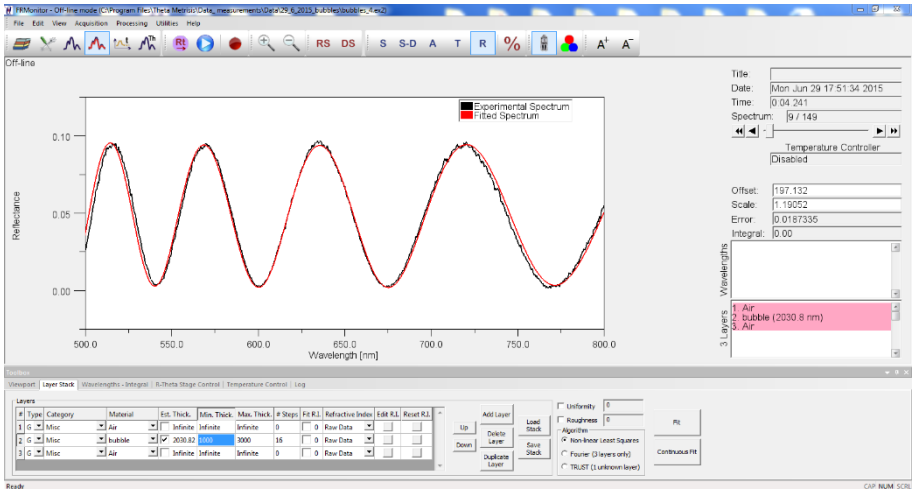
Cover slip No.1 from Corning. Thickness: 148.6µm



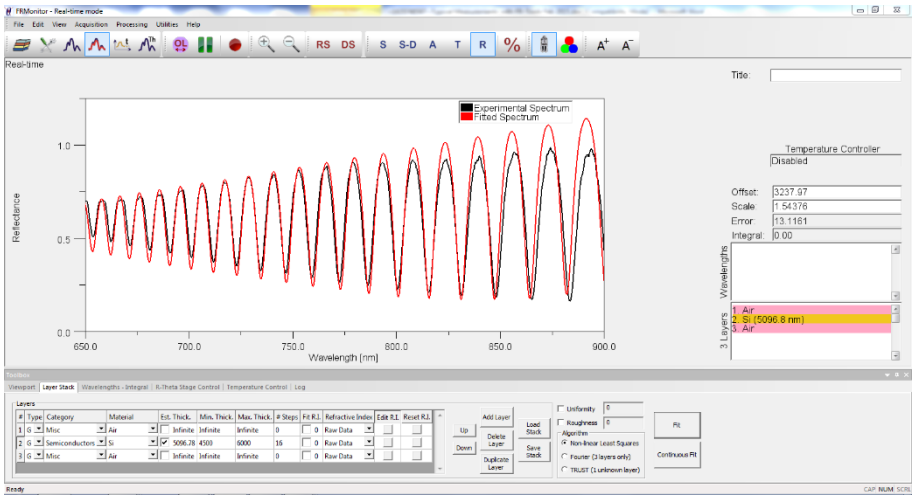
Fischer Scientific cover slip. Thickness: 210.8µm

MEASUREMENT OF THE THICKNESS OF UN-SUPPORTED FILMS

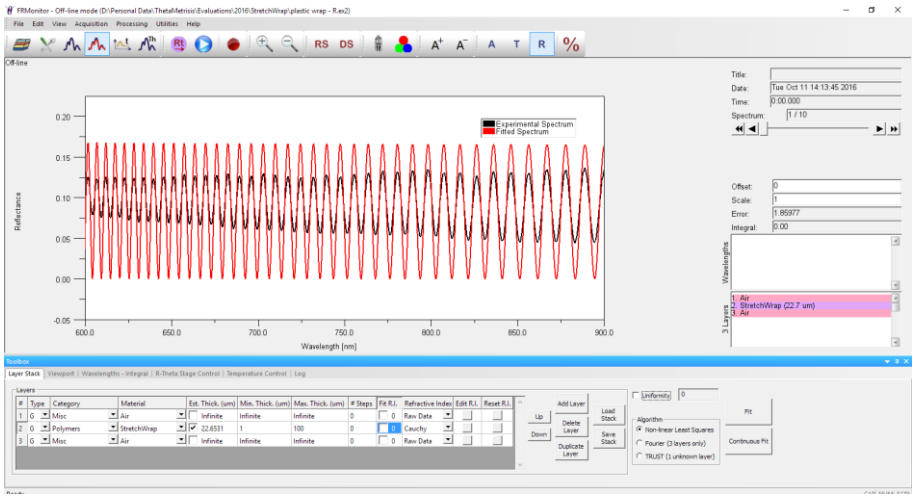
In addition to the standard thickness measurements of films coated on substrates, FR-Tools are able to analyze the reflectance spectra of un-supported samples and to measure film thickness and all other optical properties (refractive index, transmittance, reflectance….).



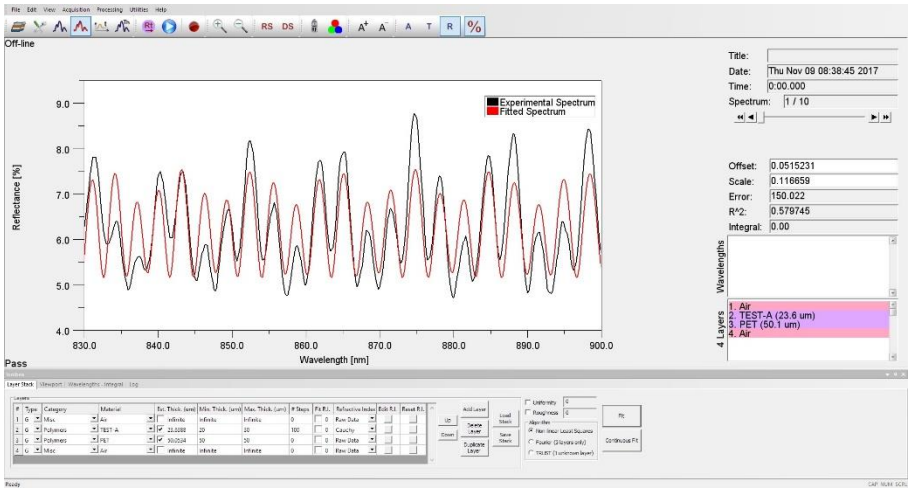
Thickness measurement of a "Soapy" membrane standing on a ring of a holder. Thickness: 2.03µm



Si membrane prepared by Silicon wafer bonding technique and sacrificial silicon dioxide layer. Thickness: 5.09µm.



Thickness measurement of a standard Stretch Wrap. Thickness: 22.7 µm.

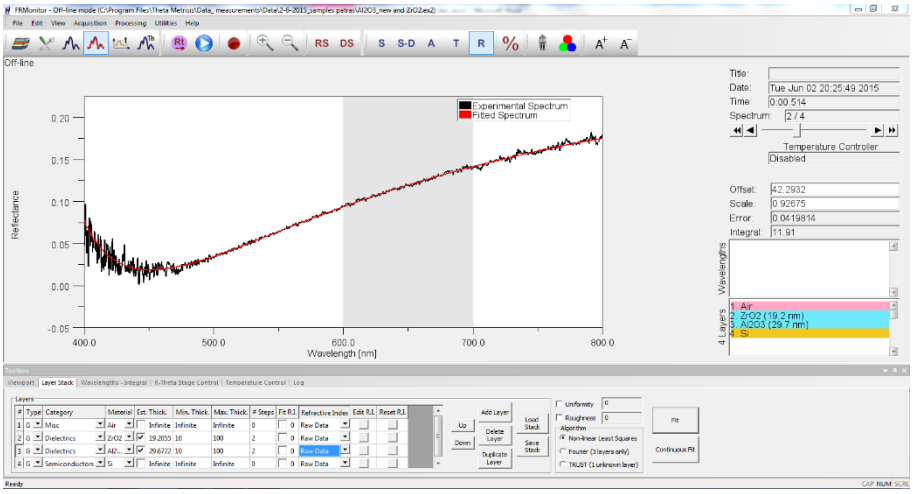


Simultaneous thickness measurement of a PET film and its coating (“TEST-A”) on top. Thickness of PET measured to be 50.1 µm, and coating 23.6 µm.

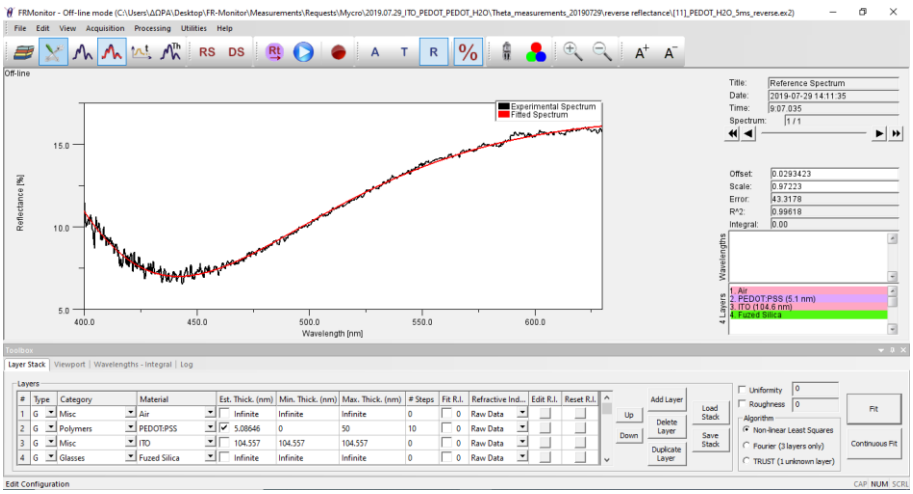
MEASUREMENT OF THICKNESS IN MULTI-LAYER FILMS

In addition, to the case of single films, FR-tools are extensively used for the simultaneous measurement of film thicknesses of stack of films. The maximum number of films that can be characterized simultaneously, depends on the optical properties of the individual films and in particular on the refractive index contrast, i.e. the difference between the refractive index between adjacent films. In the following graphs characteristic cases of the characterization of various multilayer films are illustrated:

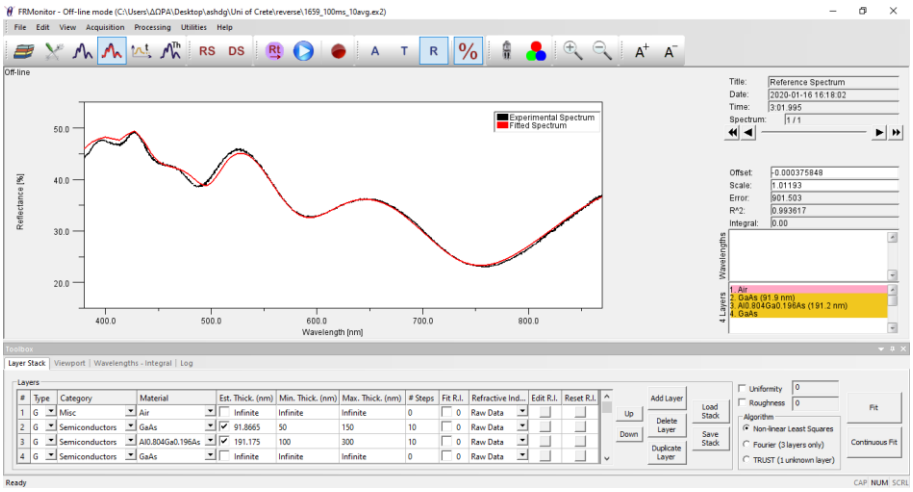
- Two layers stack (two dielectric layers)
- Three layers stack (two dielectric layers, one semiconductor)
- Five layers stack



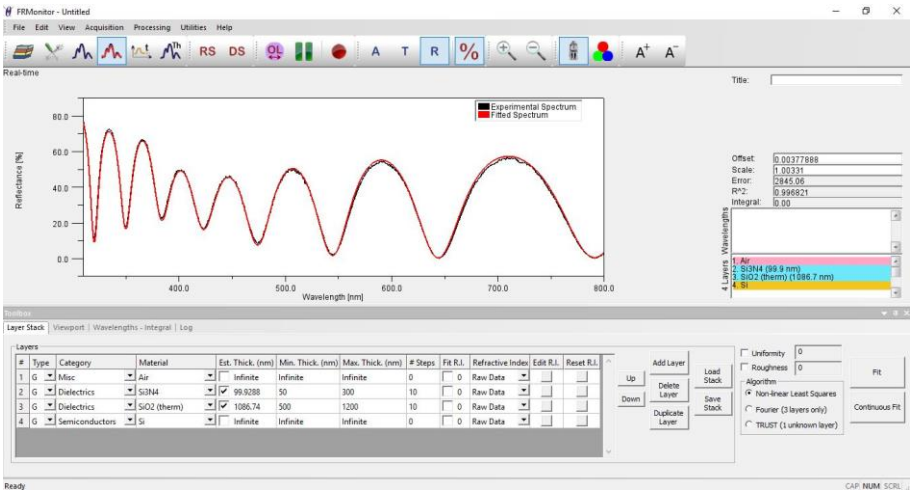
ZrO_2 (19.2 nm)/Al_2O_3 (29.7 nm) on Si wafer.



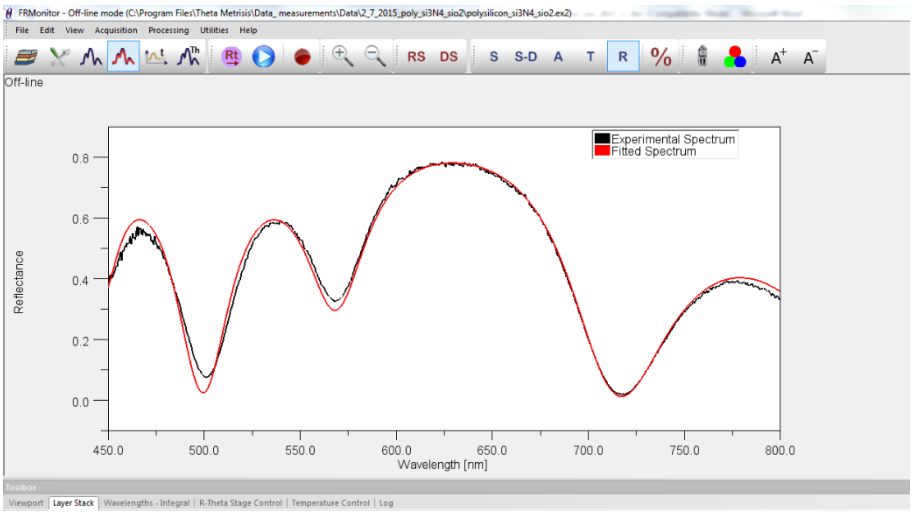
PEDOT (5.1nm)/ITO (104.6nm) on Fused Silica wafer.



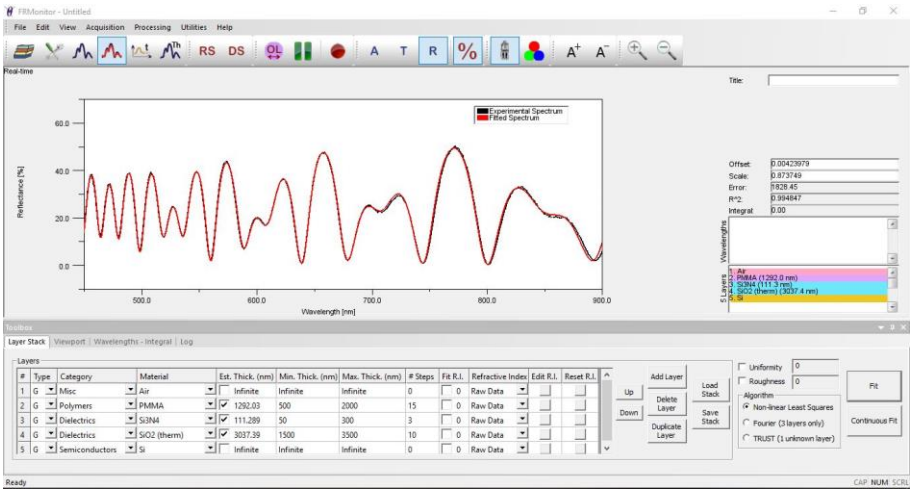
GaAs (91.86 nm)/$Al_{0.804}Ga_{0.196}As$ (191.17 nm) on GaAs wafer.



One film of Si_3N_4 (99.9 nm) on thermal SiO_2 (1086.7 nm) on Si wafer.

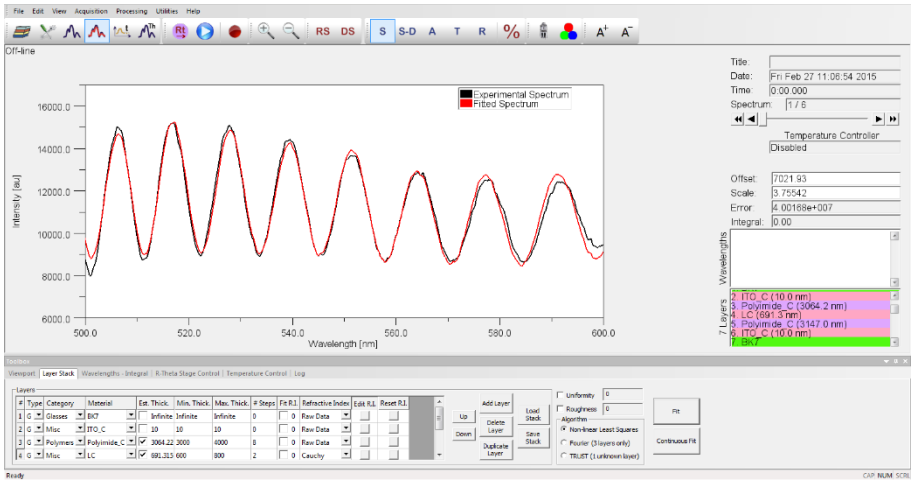


poly-Si (115.1nm)/Si_3N_4 (148.2nm)/SiO_2 (569.4 nm) on Si wafer.



PMMA (1292.0nm)/Si_3N_4 (111.3nm)/SiO_2 (3037.4nm) on Si wafer.

In the case of multilayers of repeating films the option of linked layers can be activated. In this option the film thickness is considered constant for the selected layers and the software finds deviation in the estimated film thickness. In the following screenshot, the case of five layers stack of ITO/polyimide/LC/polyimide/ITO on BK7 glass is illustrated. The fitting process was applied for the three layers (polyimide/LC/polyimide) while the thickness of ITO is fixed at 10 nm.



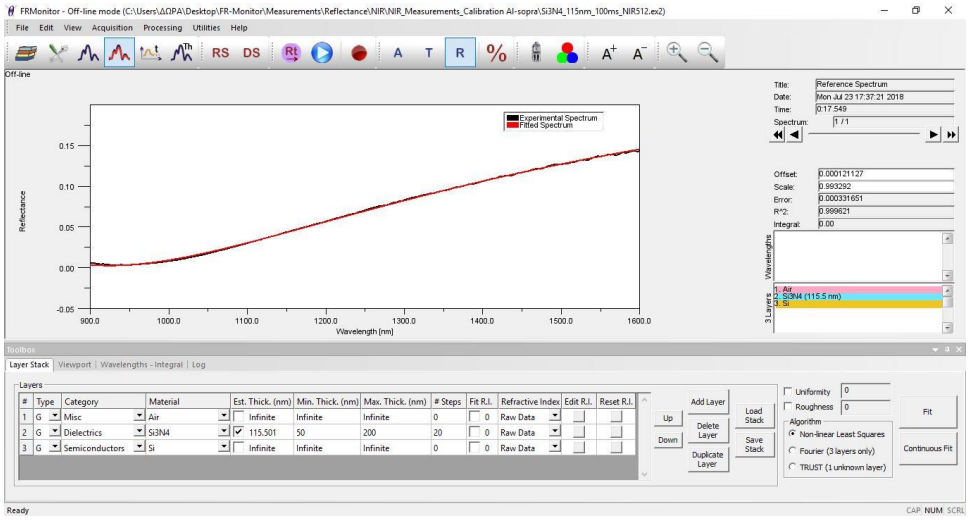
5 layers stack of ITO/polyimide/LC/polyimide/ITO on BK7 glass.

layers	*Thickness*
BK7	Infinite
ITO	10 nm (fixed)
Polyimide	3064.2 nm
LC	691.3 nm
Polyimide	3147.0 nm
ITO	10 nm (fixed)
BK7	infinite

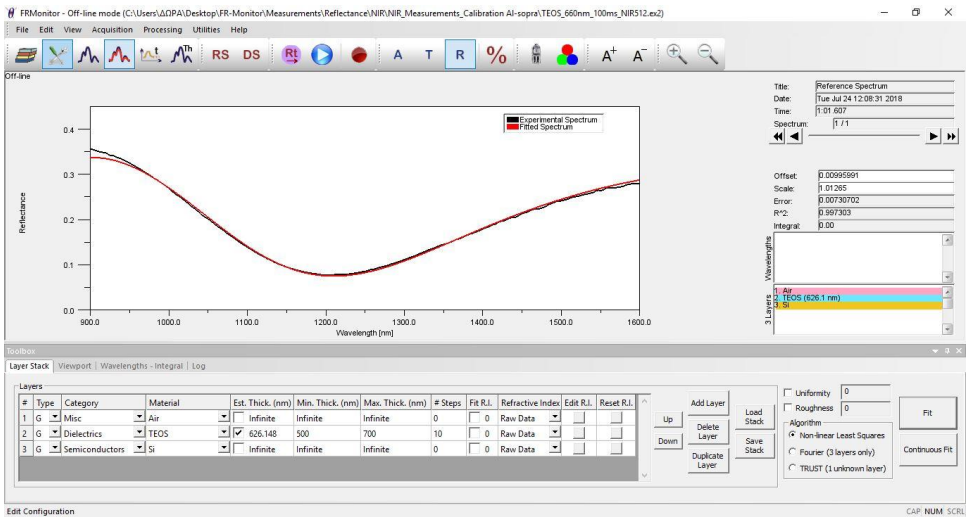
NIR measurements (900-1700nm, wavelength)

For the thickness measurement of conventional and ultra-thick films in the 100nm to 1000µm range, an FR-pRo tool with spectrometer tuned to operate in NIR is employed. In the following screen-shots, representative measurements of single and multi-layer films are illustrated for film thickness in the range of 100nm to 100 µm. Also the measurement of thickness of Si wafer is also demonstrated.

Conventional films (100nm-1000nm)

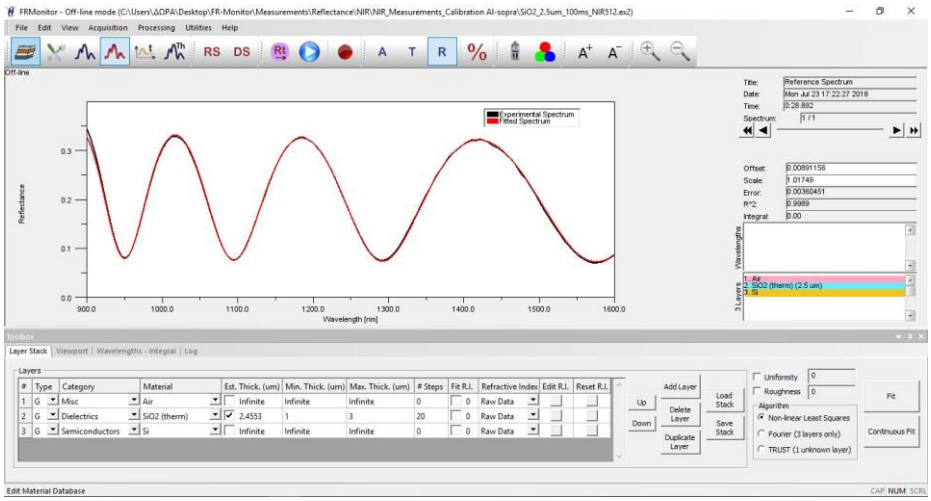


Si_3N_4 on Si wafer. Si_3N_4 film thickness=115.5 nm

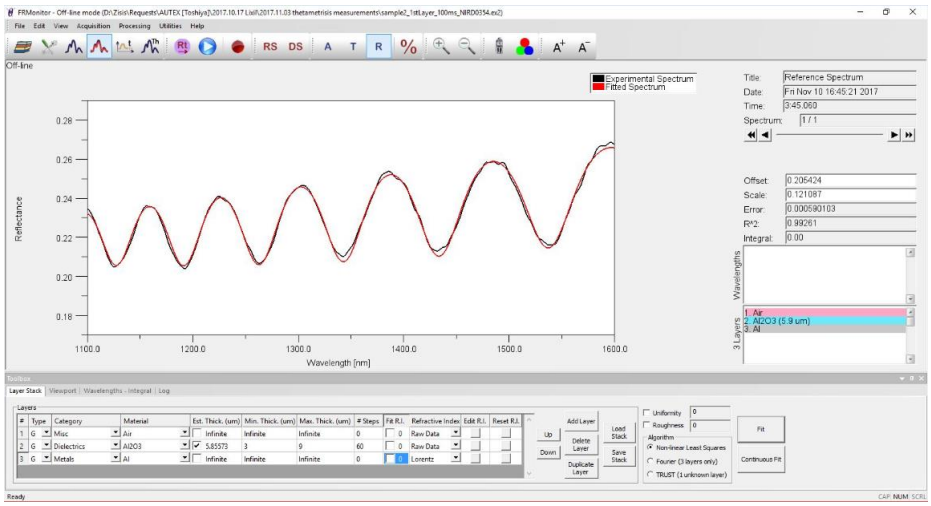


TEOS on Si wafer. TEOS film thickness=626.1 nm

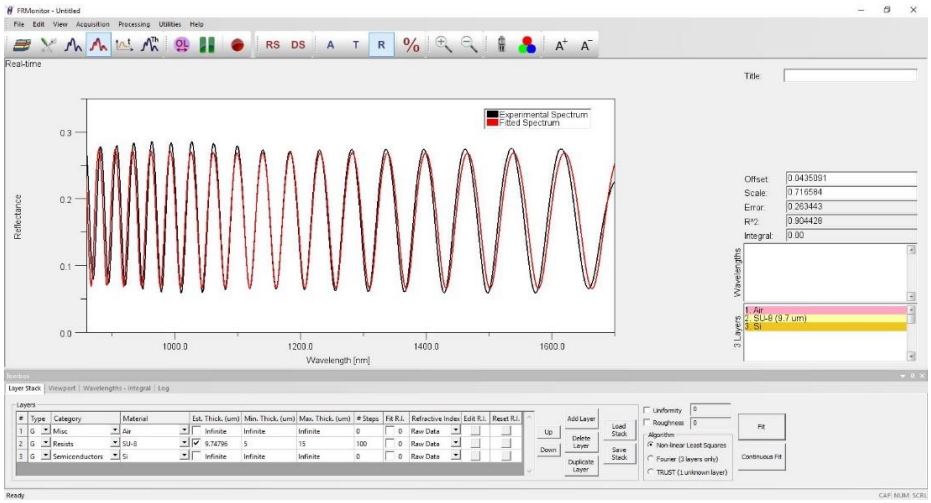
Thick films (1µm-10µm)



SiO_2 on Si wafer. SiO_2 film thickness=2.45µm.

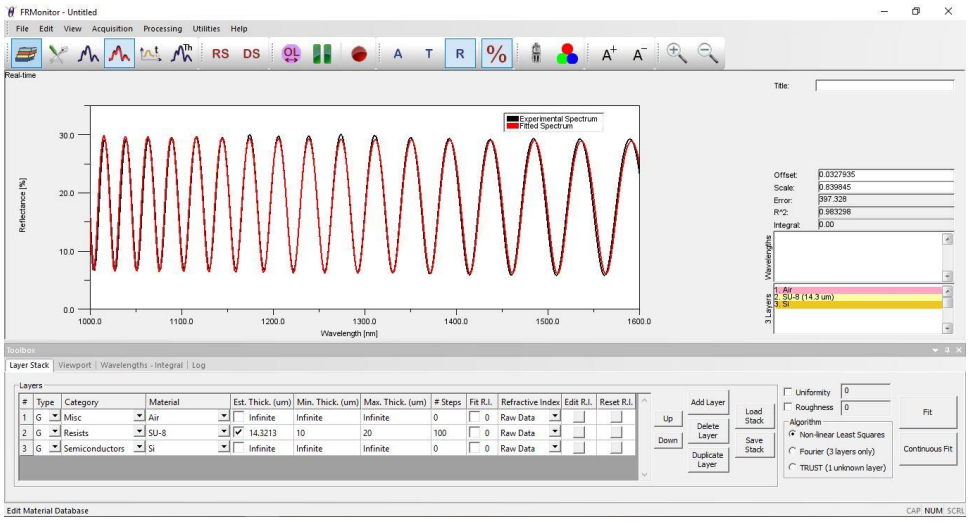


Al_2O_3 on Al wafer. Al_2O_3 film thickness=5.85µm.

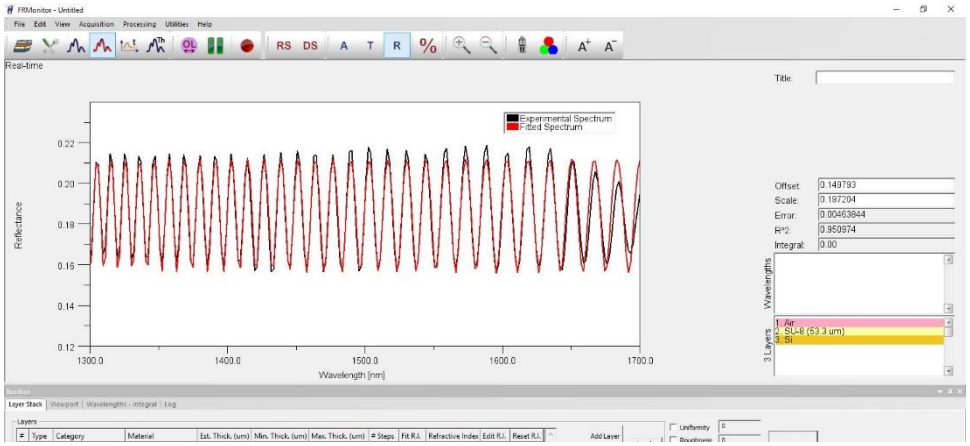


SU-8 on Si wafer. SU-8 film thickness=9.75µm

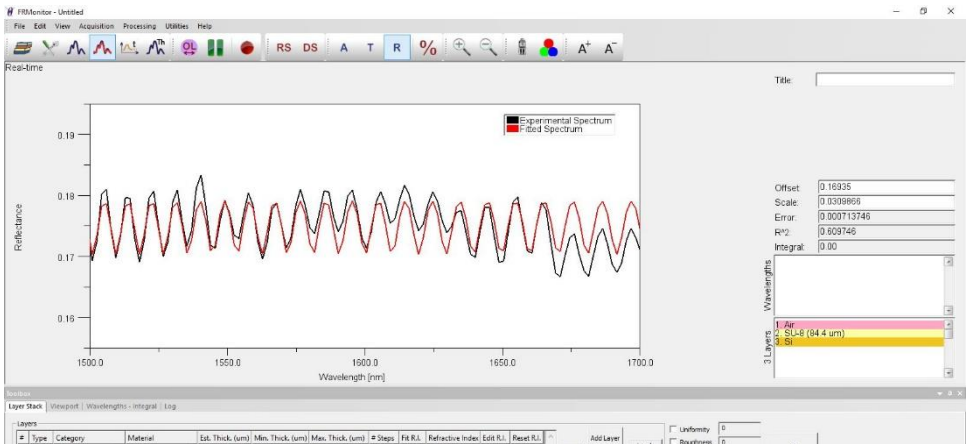
Very Thick films (10um-100um)



SU-8 on Si wafer. SU-8 film thickness=14.3µm

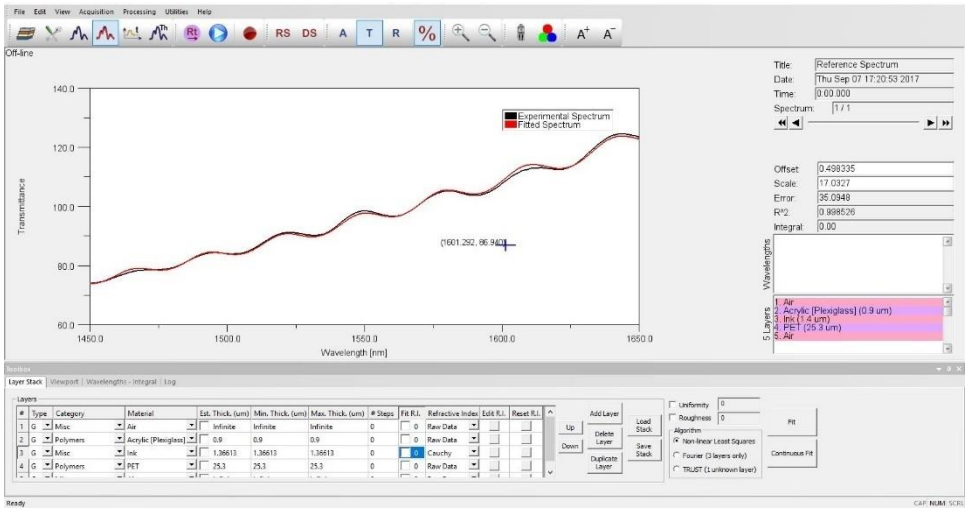


SU-8 on Si wafer. SU-8 film thickness=53.3µm



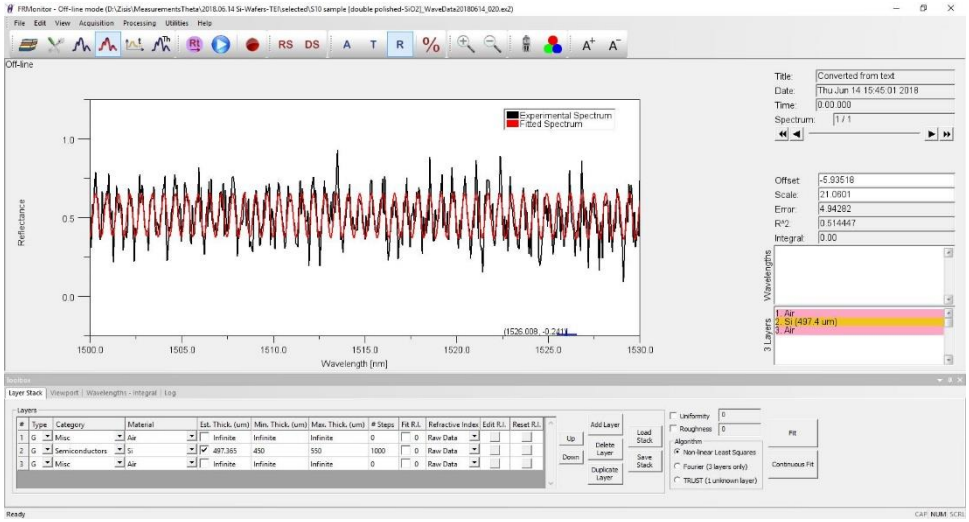
SU-8 on Si wafer. SU-8 film thickness=84.3µm

Multi-layer films



3-layer thickness measurement: Acrylic on top of a layer of Ink, on top of a PET film.
Acrylic layer thickness = 0.9µm
Ink layer thickness = 1.36µm
PET layer thickness = 25.3µm

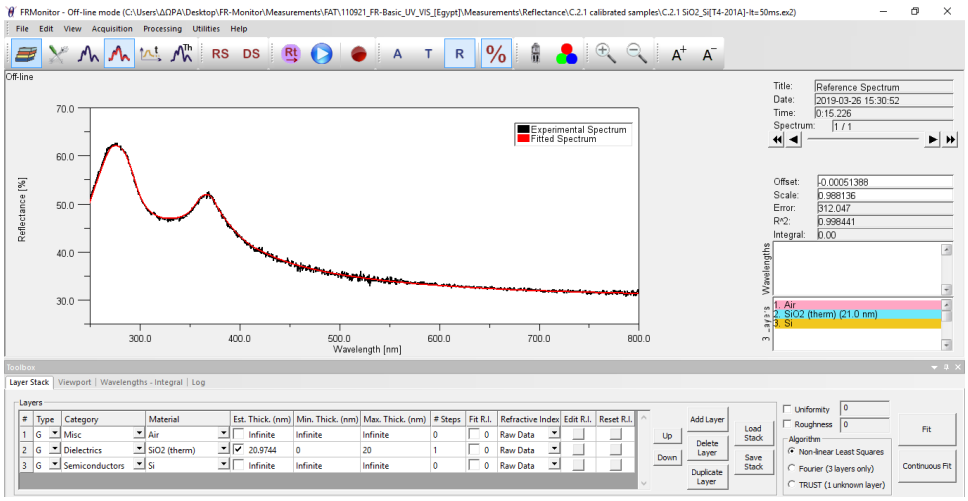
Substrate thickness



Si wafer. Si thickness=497.4µm

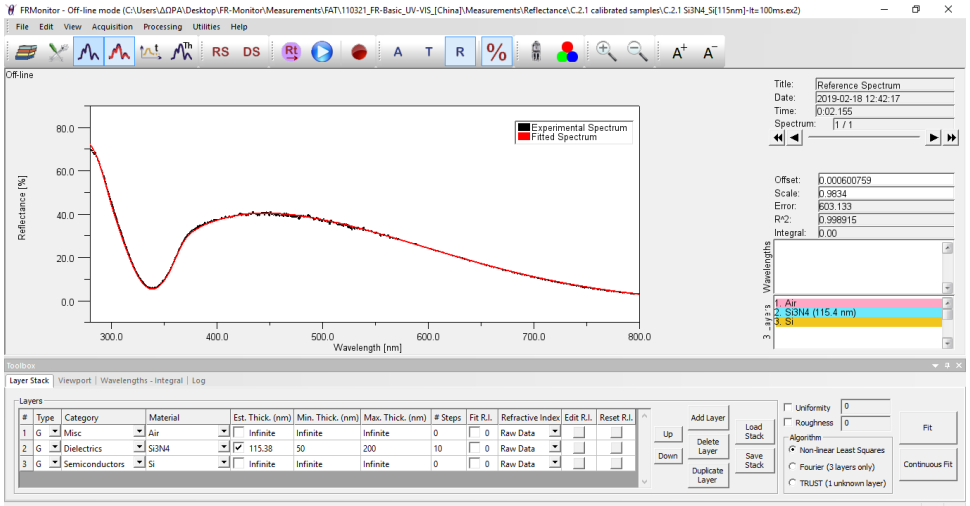
MEASUREMENTS OF THE THICKNESS USING FOCUSING MODULE

Thin films (10nm- 100nm)

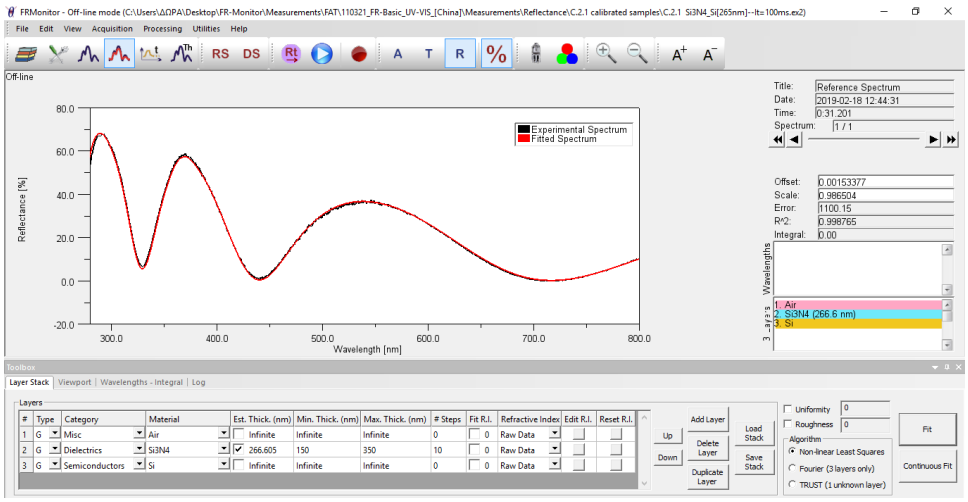


SiO_2 on Si wafer. SiO_2 film thickness=20.97 nm

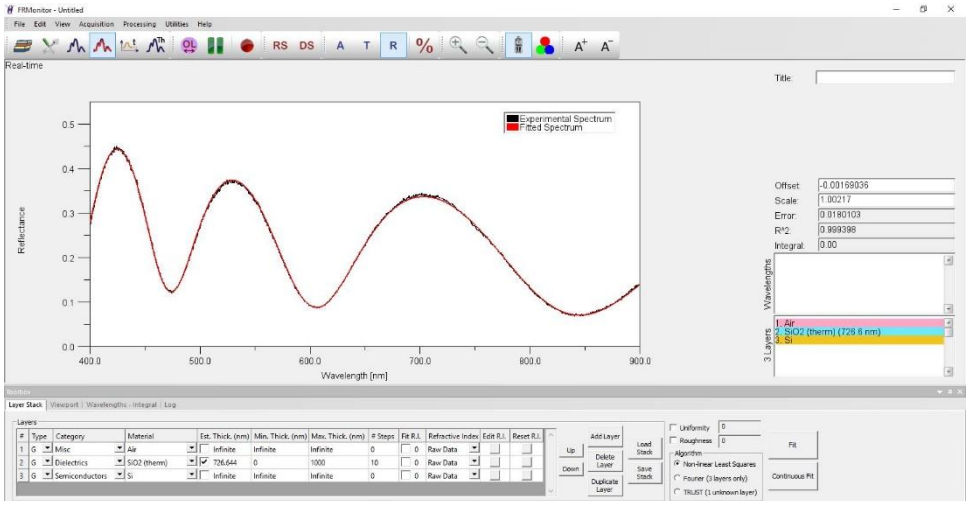
Conventional films (100nm-1000nm)



Si_3N_4 on Si wafer. Si_3N_4 film thickness=115.4 nm

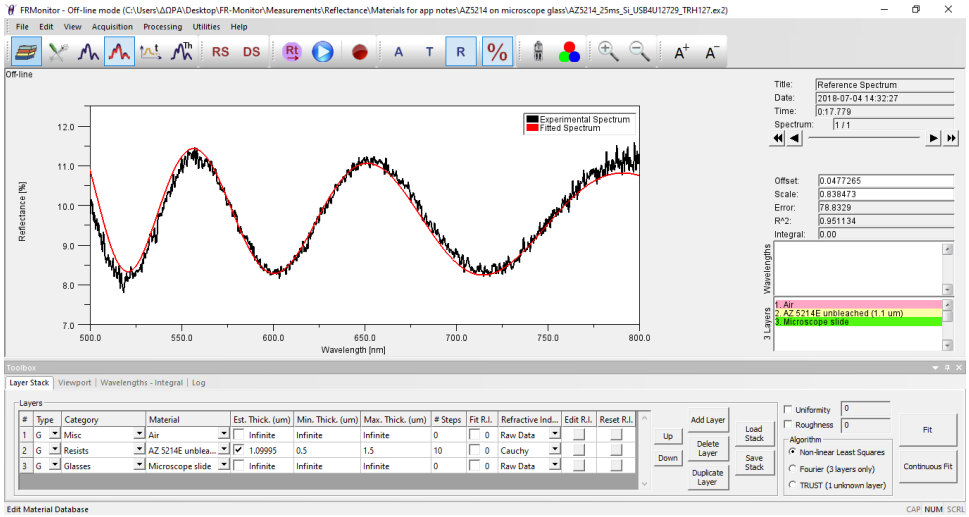


Si_3N_4 on Si wafer. Si_3N_4 film thickness =266.6 nm

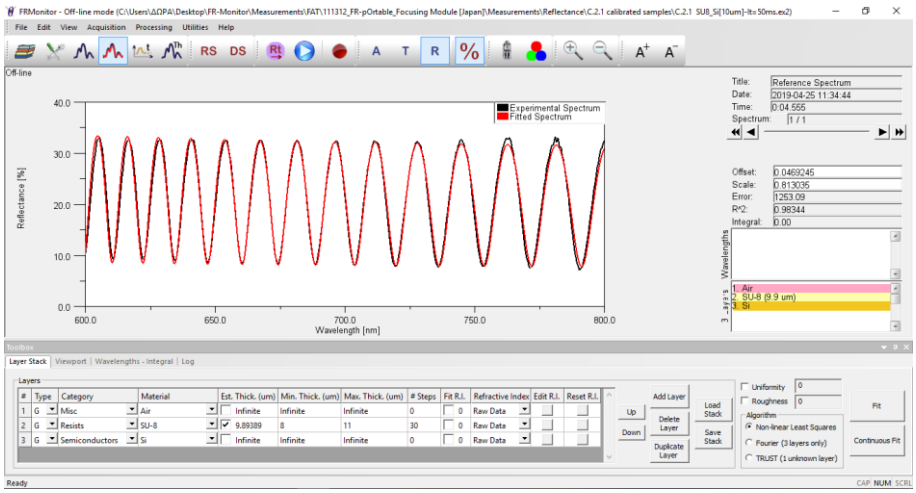


SiO_2 on Si wafer. SiO_2 film thickness =726.6 nm

Thick films (1µm-10µm)

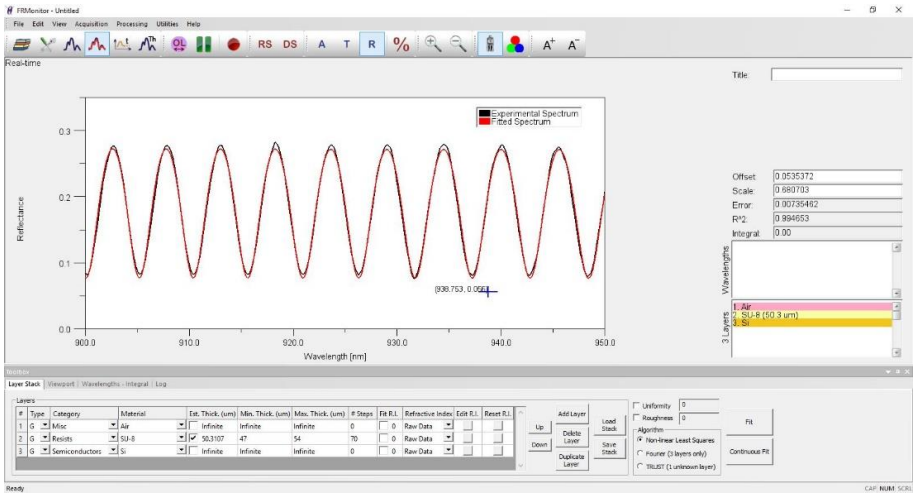


AZ5214 on microscope glass. AZ5214 film thickness: 1.09 µm



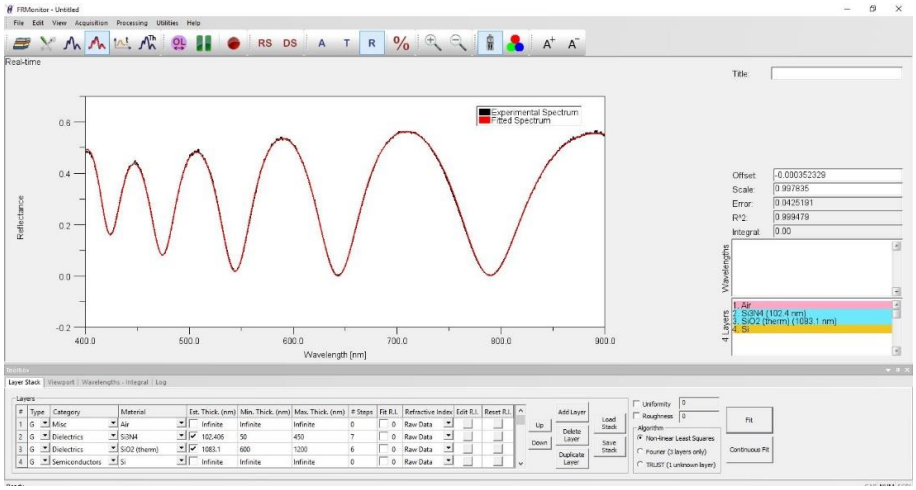
SU-8 on Si wafer. SU-8 film thickness =9.9µm

Very Thick films (10µm-100µm)



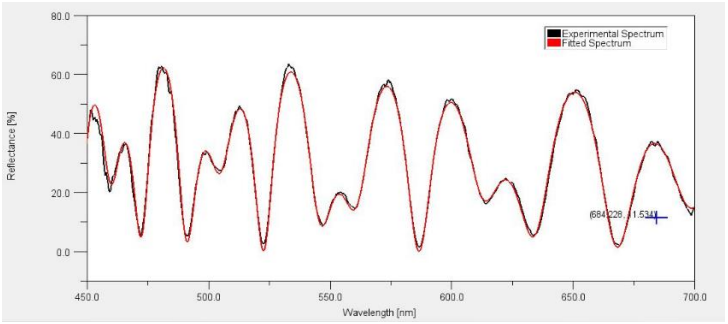
SU-8 on Si wafer. SU-8 film thickness =50.3µm

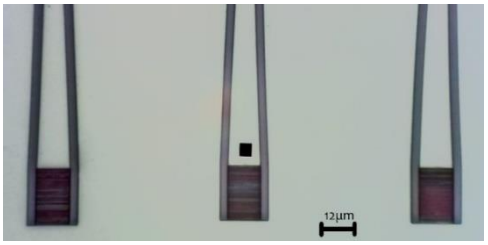
Multilayer films



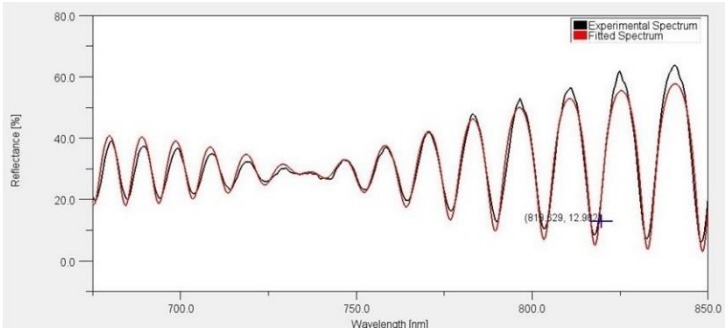
Si_3N_4 (102.4nm) film on SiO_2 (1083.1 nm) film on Si substrate

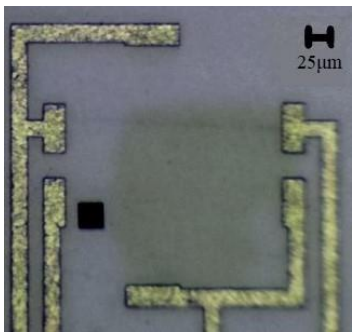
MEASUREMENTS OF THE THICKNESS USING FR-uProbe



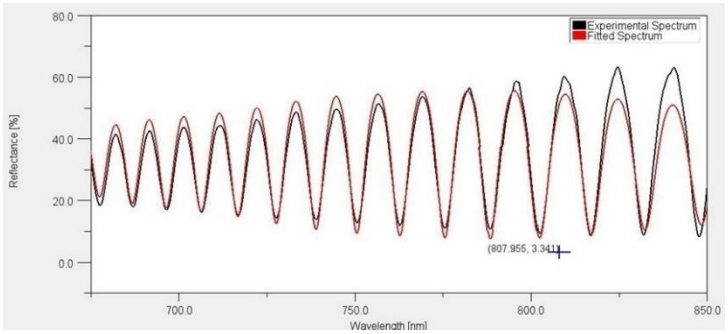


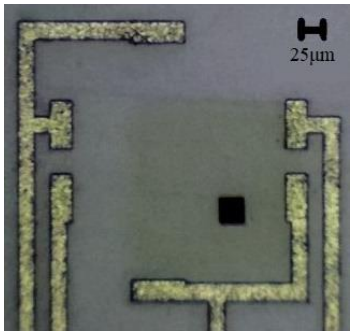
UV5 resist (1520.6nm) film on Si_3N_4 (202.2nm) film on SiO_2 (3090.7 nm) film on Si substrate





SOI area on a MEMS pressure sensor. Si (5320.1nm) film on SiO_2 (759.2 nm) film on Si substrate





Suspended Silicon area on a MEMS pressure sensor. Si (5329.1nm) film on SiO_2 (759.2 nm) film on Si substrate