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Determination of CdS Thin-film Parameters from Optical Reflectance and Transmittance Measurements

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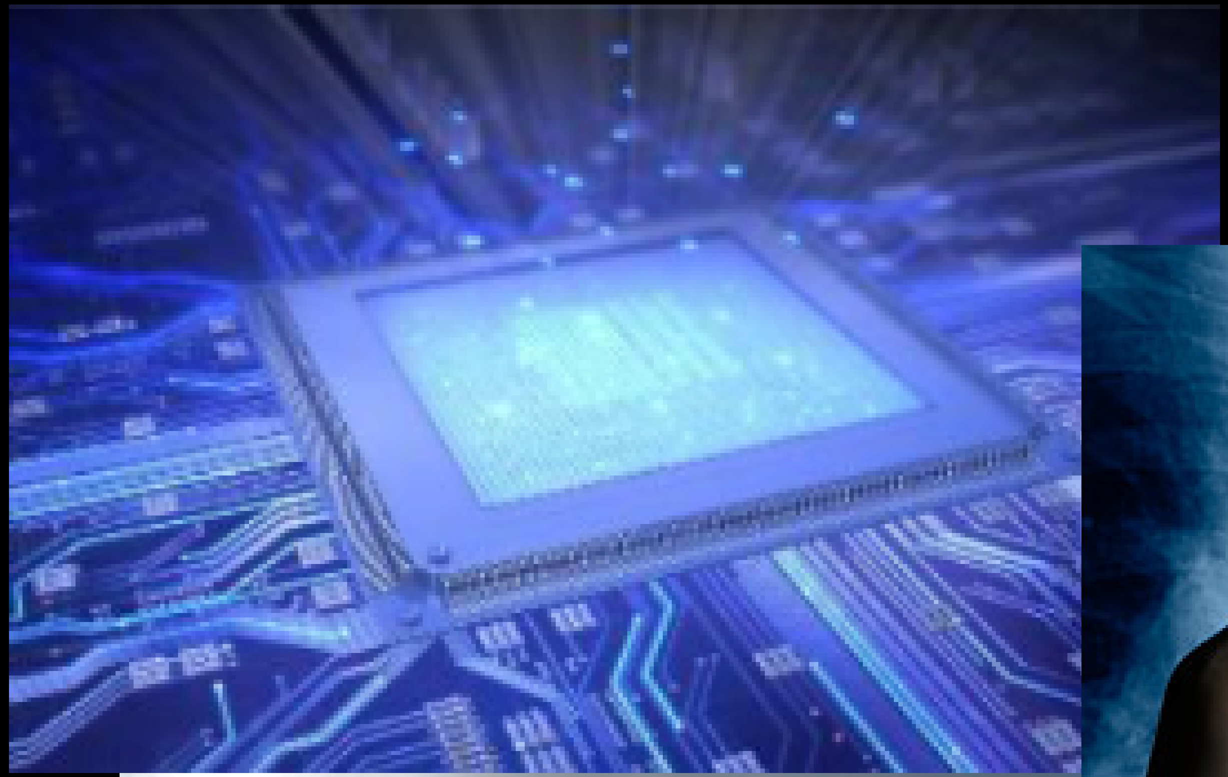
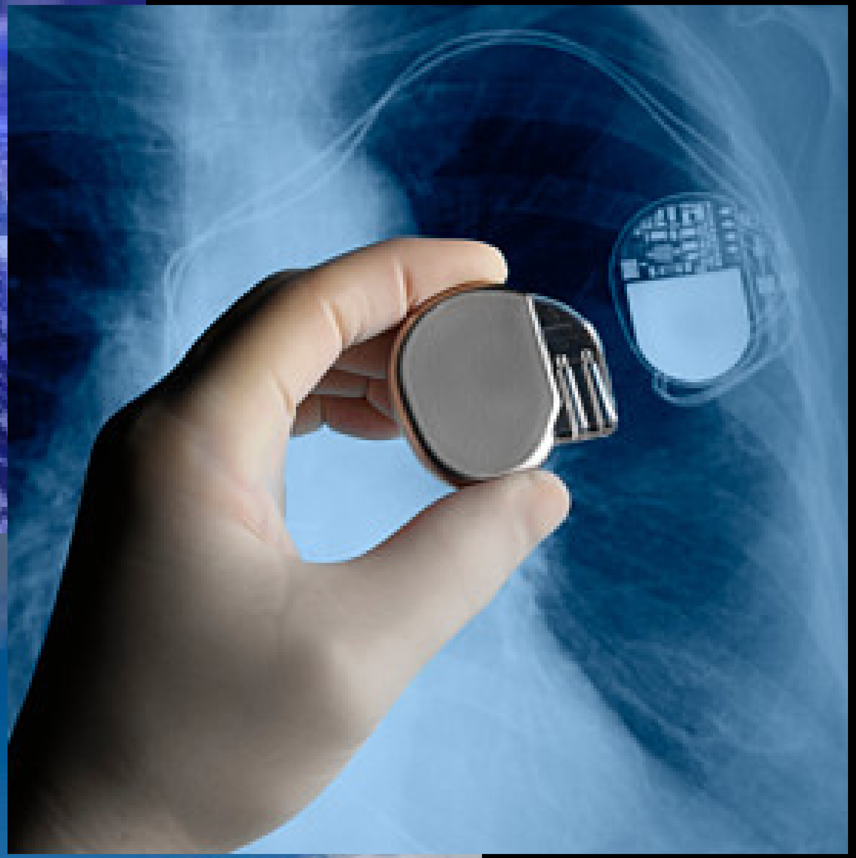
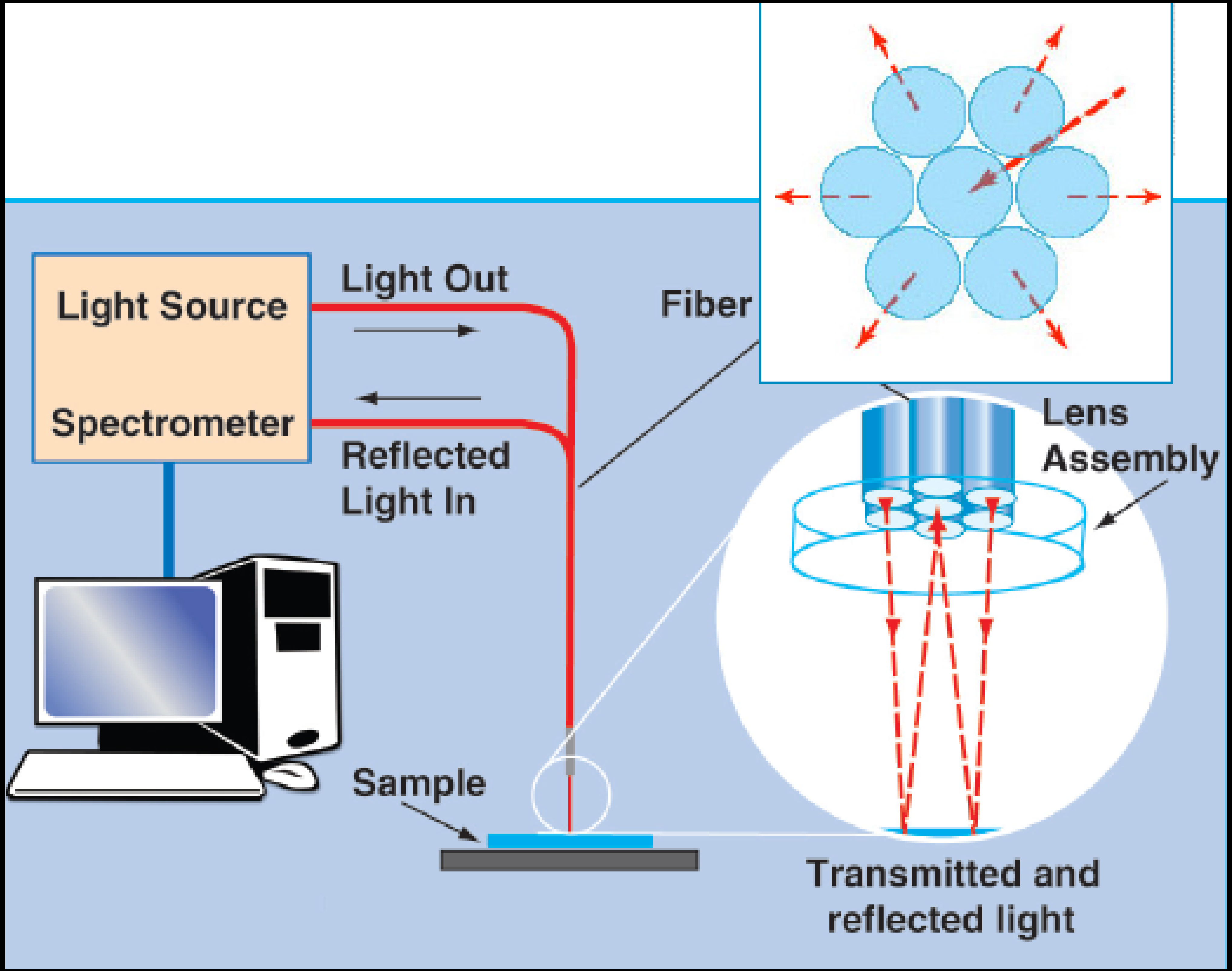
Thin Film Applications





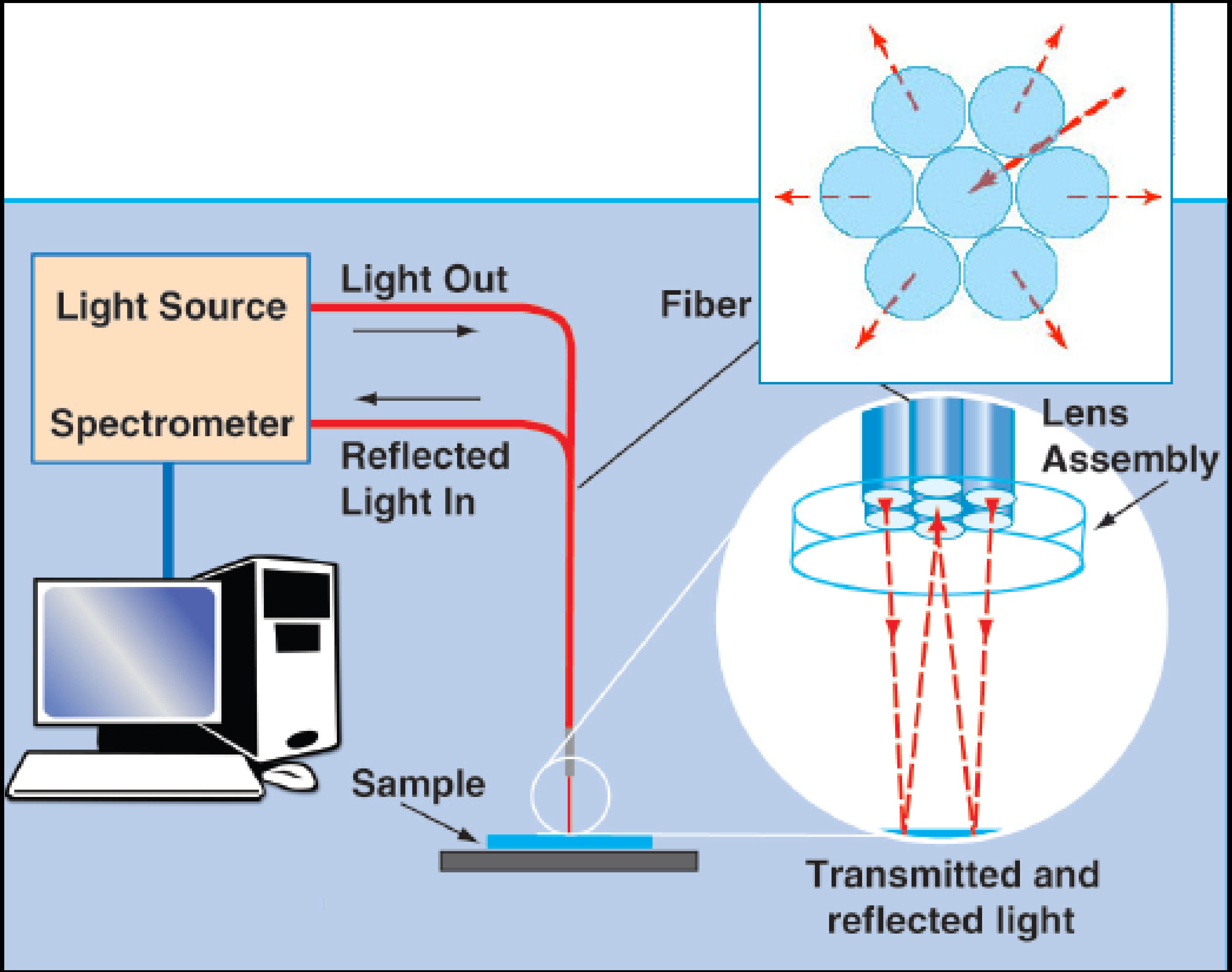
Precise determination of thickness and optical constants of thin films and nanolayers is of key importance for many applications, since these parameters define the functional properties of layers and effectiveness of the application.

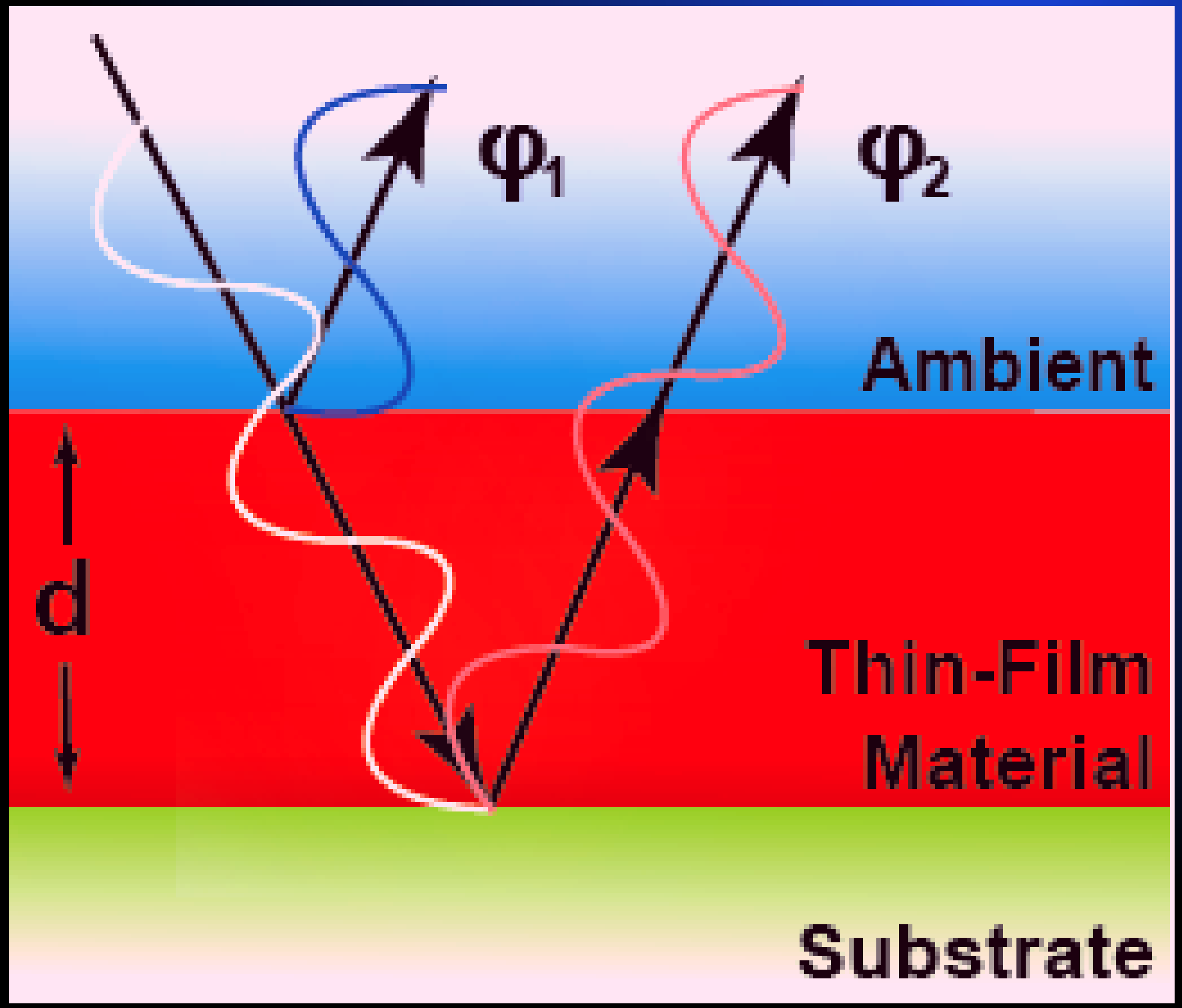
The Measurement Technique: Spectral Reflectance Measurement (SRM)



- film thickness
- complex refractive index
- absorption edge
- surface roughness
- structure
- .....

The Measurement Technique: Spectral Reflectance Measurement (SRM)





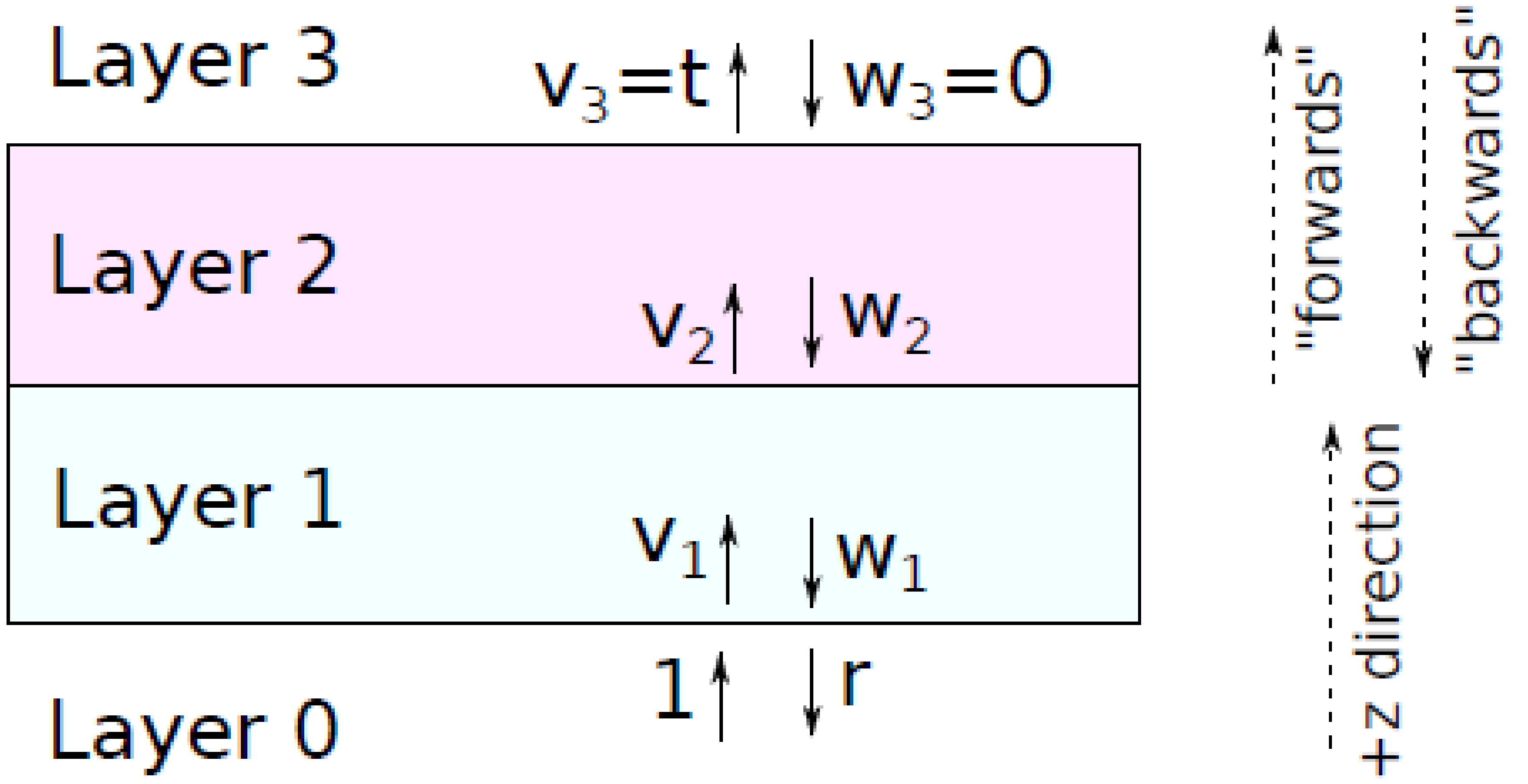
$$R = A + B \cos 4\pi nd/\lambda$$

The Computational Method

Transfer Matrix Method (TMM) of Optical Calculations for Multilayer Structures

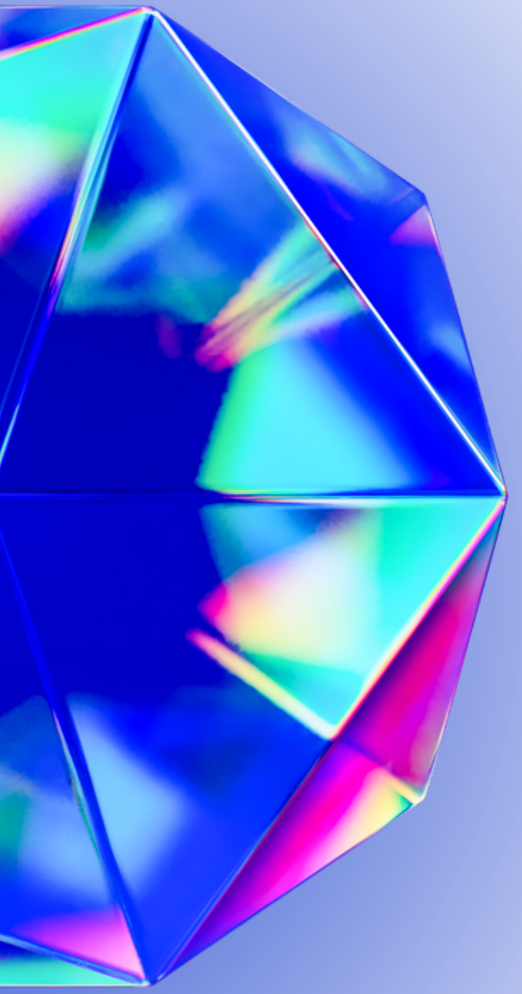
$$\begin{pmatrix}1\\ r\end{pmatrix} = \begin{pmatrix}\tilde{M}_{00} & \tilde{M}_{01}\\ \tilde{M}_{10} & \tilde{M}_{11}\end{pmatrix}\begin{pmatrix}t\\ 0\end{pmatrix}$$

$$t = \frac{1}{\tilde{M}_{00}}, \qquad r = \frac{\tilde{M}_{10}}{\tilde{M}_{00}}$$



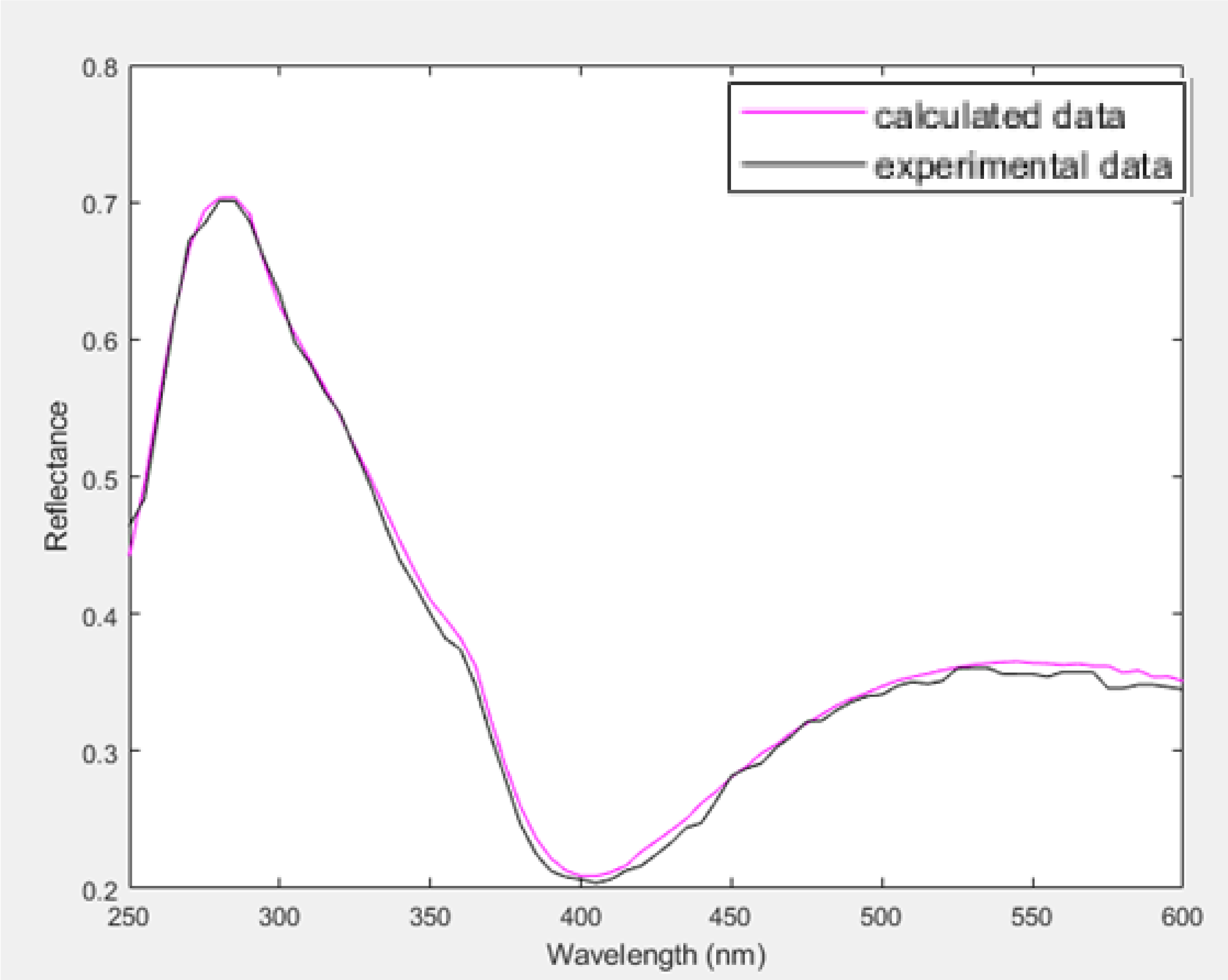
The Computational Method

Transfer Matrix Method (TMM) of Optical Calculations for Multilayer Structures



- The computing software has been developed in the MATLAB environment - real-time determination of parameters
- Curve fitting has been performed by Least Squares Method (LSM) using MATLAB built-in regression tools

Viability



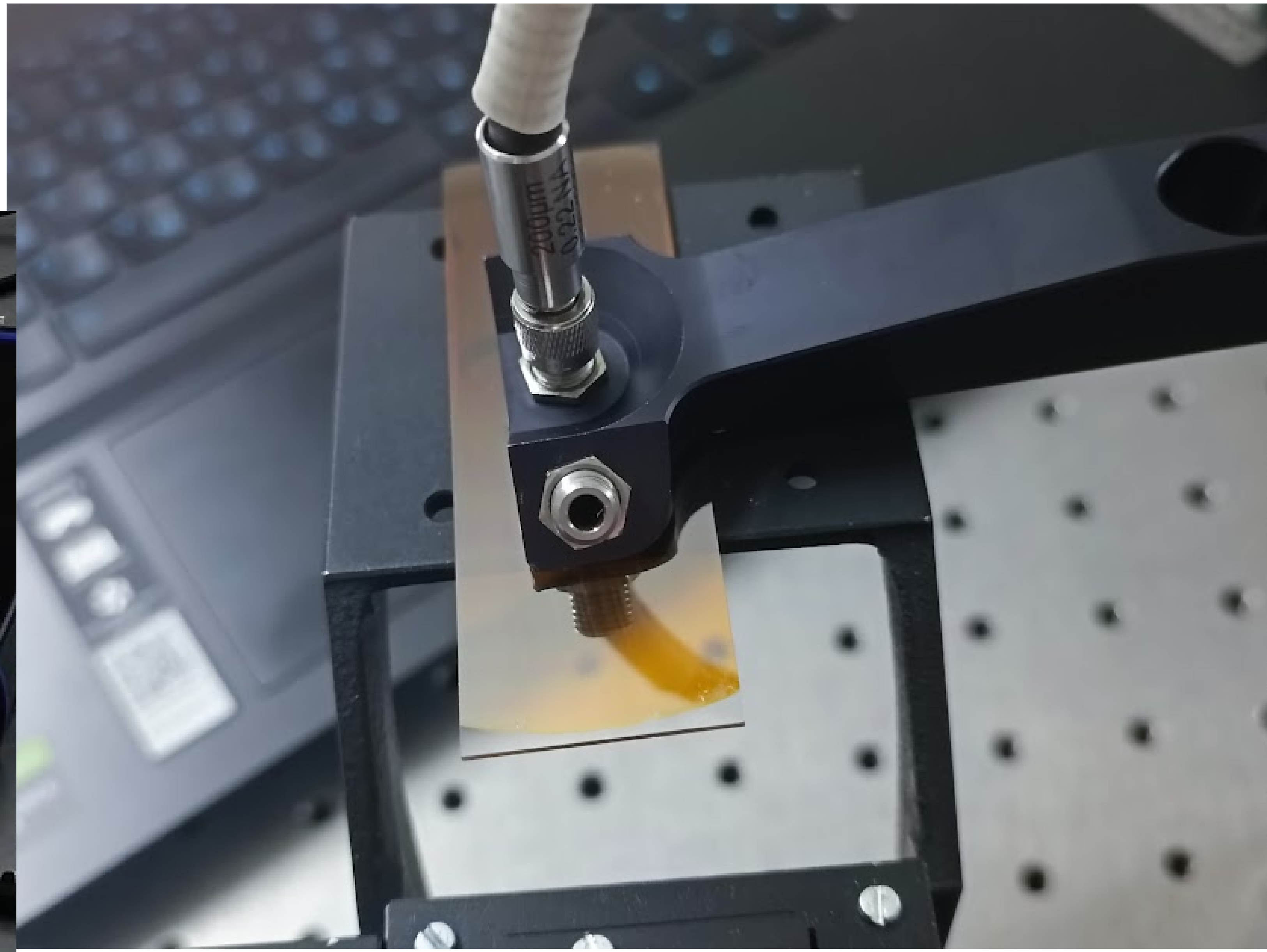
Analytical and experimental data fit for certified SiO_2-Si structure

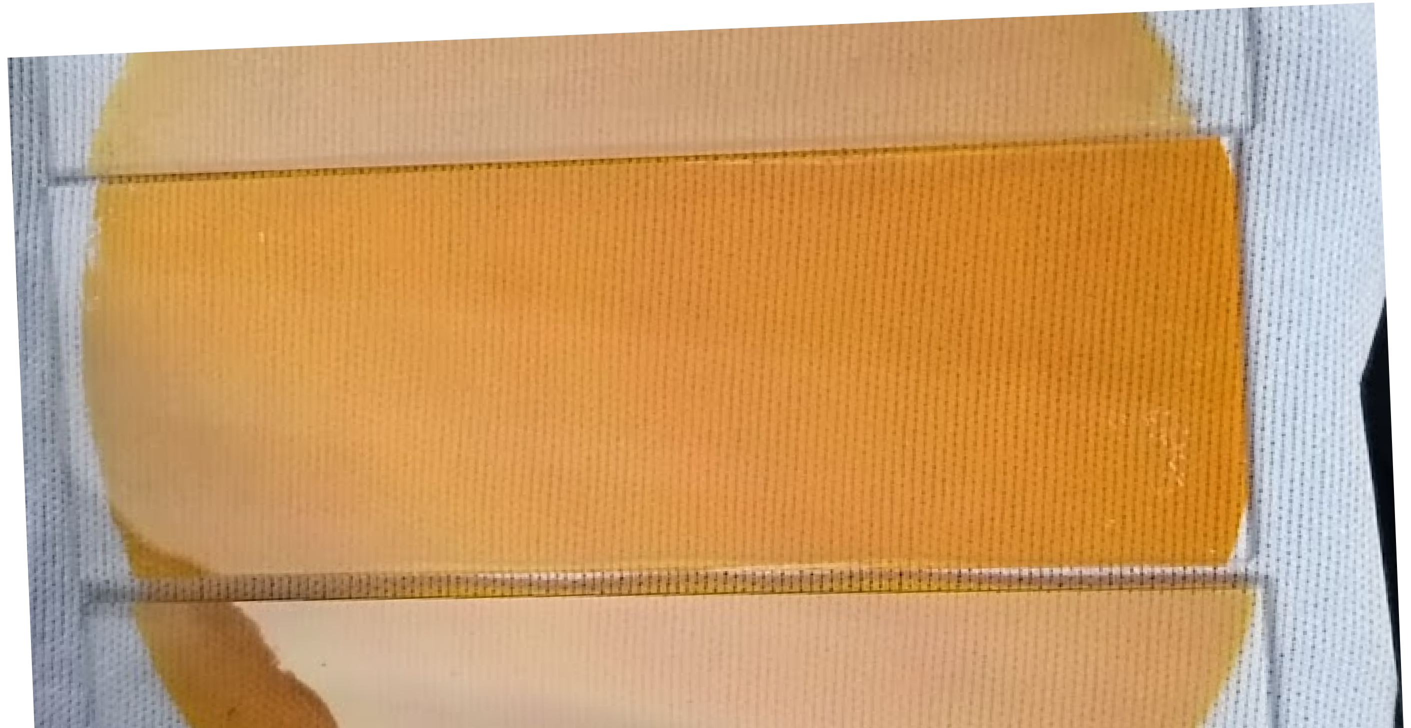
Thickness declared by manufacturer is 195.44 +- 0.34 nm

Our calculation- 195.82 nm

Fit goodness 99.66 %

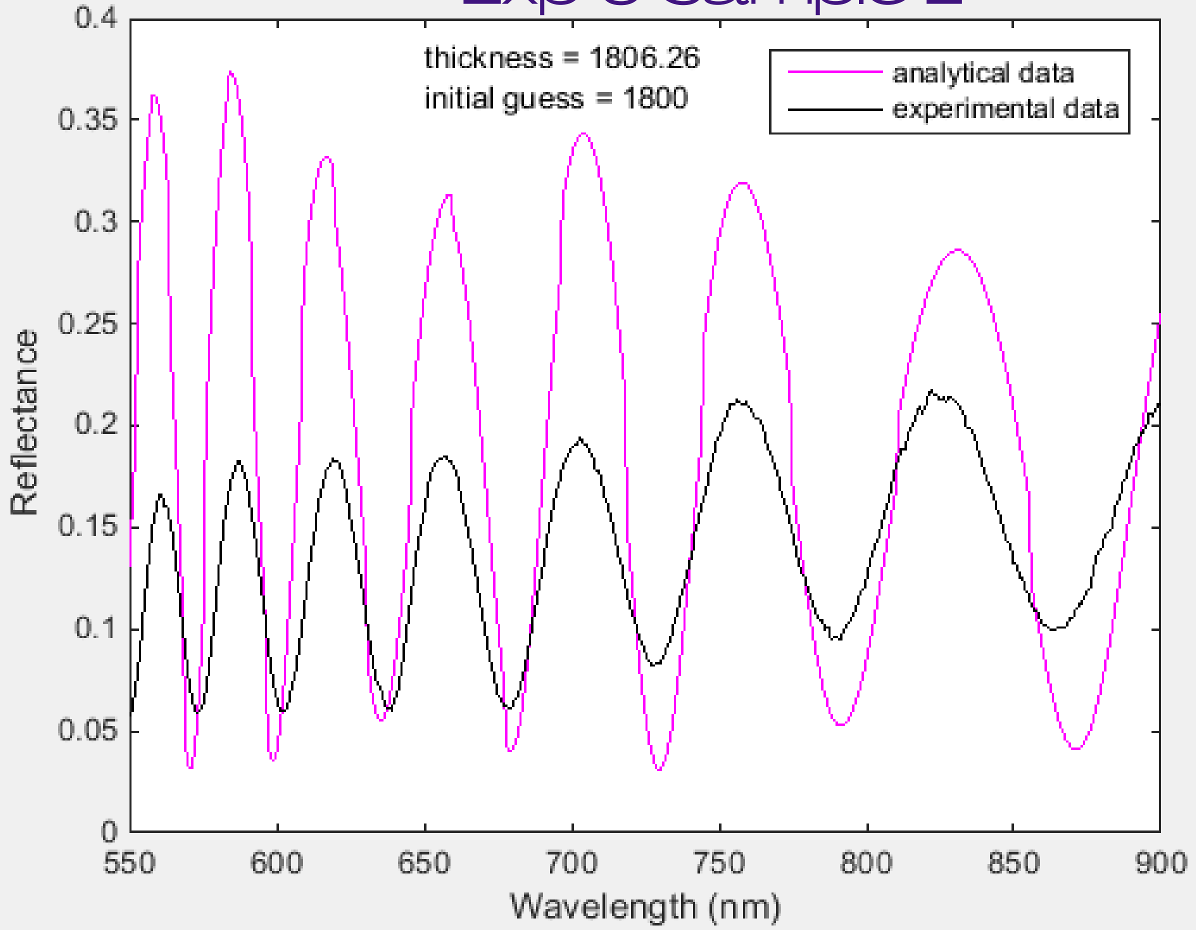
Thermal-vacuum Deposited CdS Films



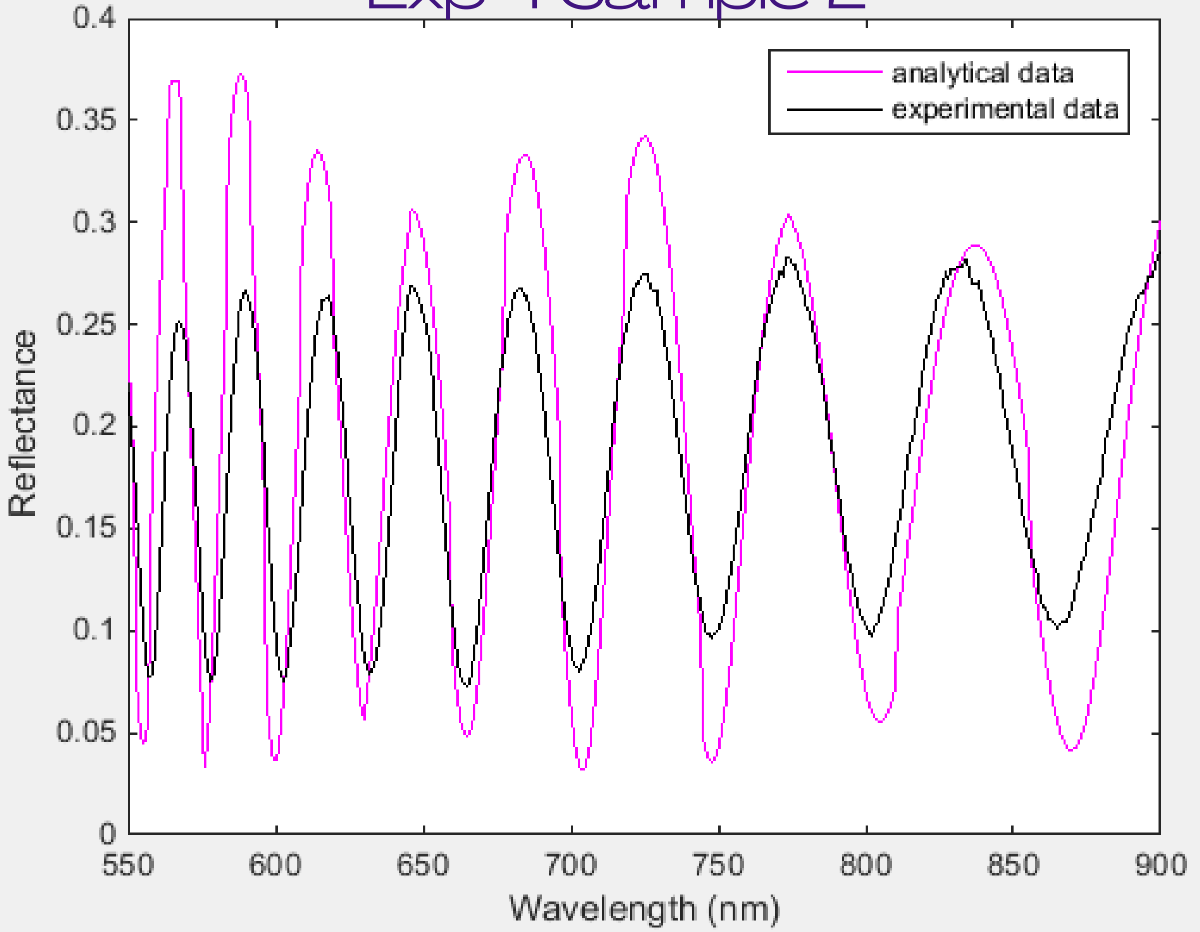


Thickness Calculations

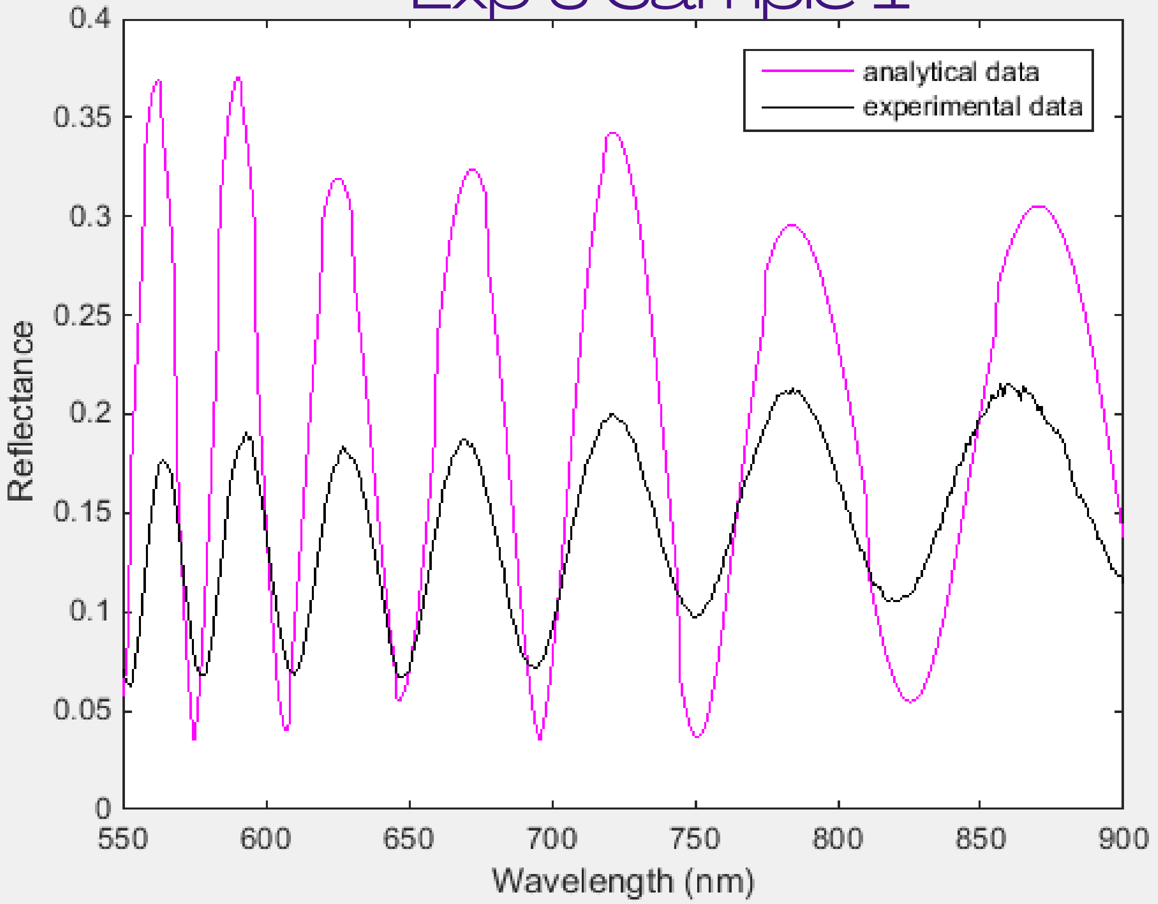
Exp 6 Sample 1



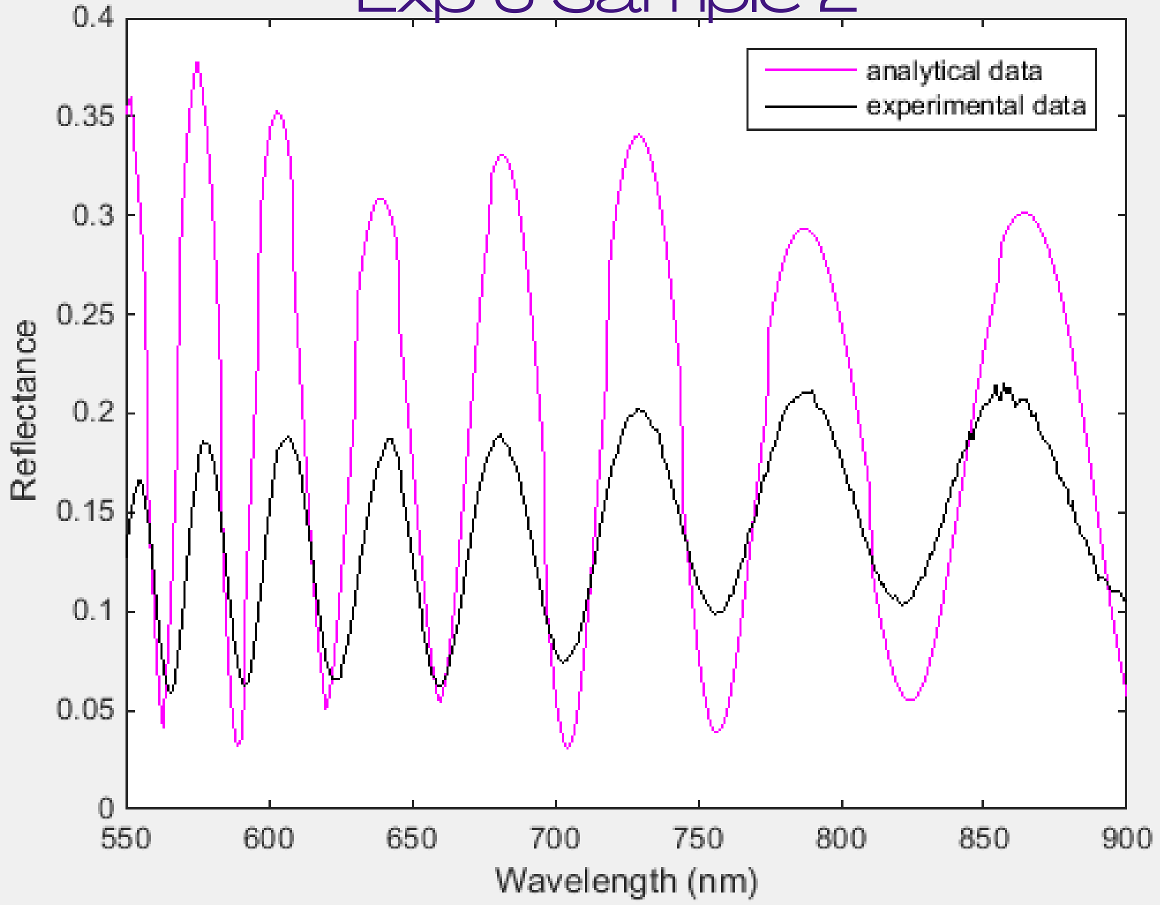
Exp 4 Sample 2



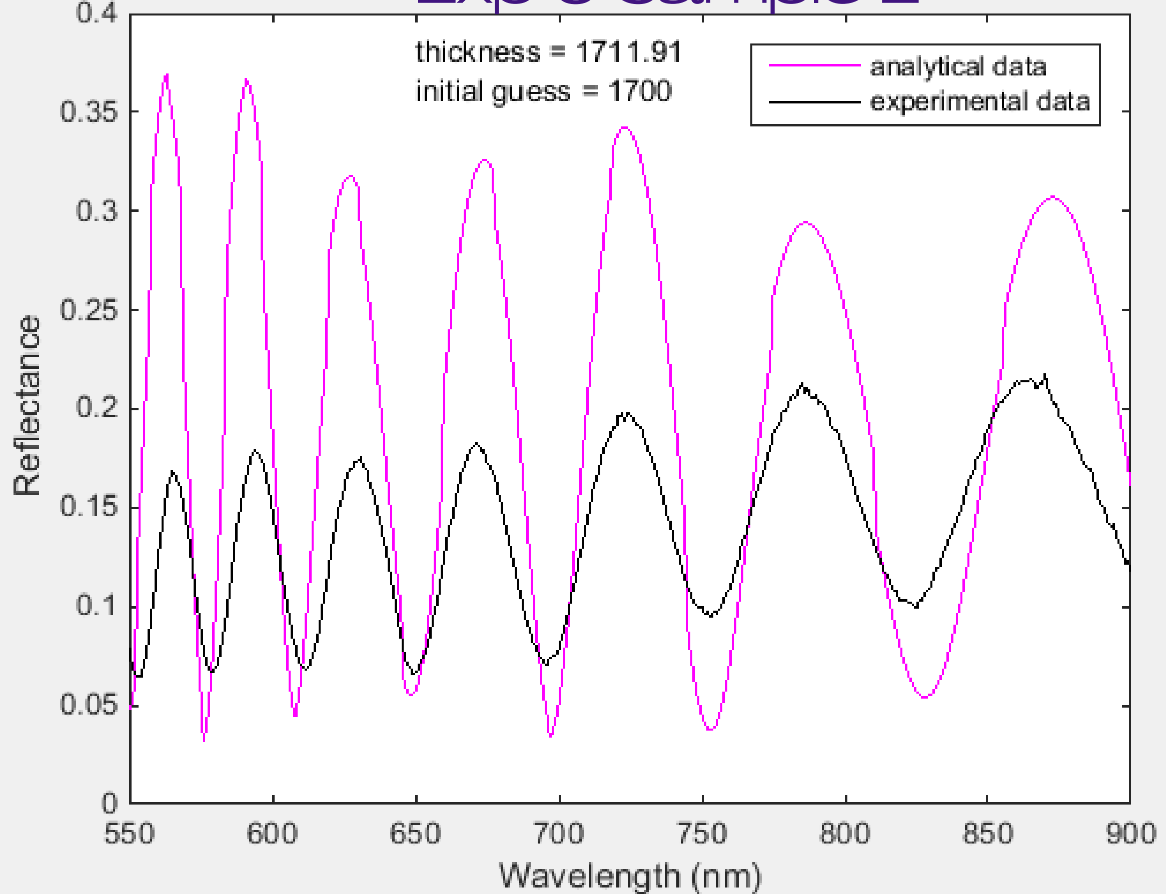
Exp 5 Sample 1



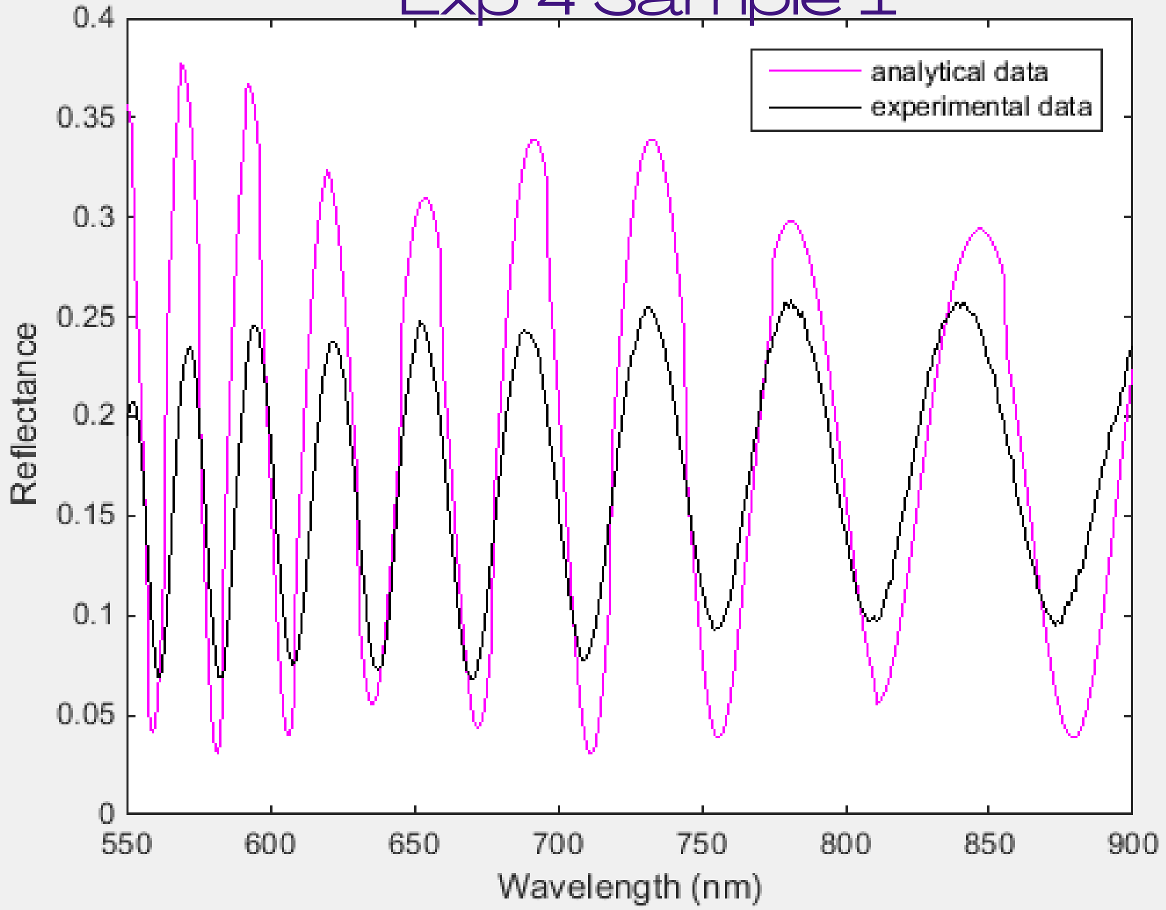
Exp 5 Sample 2



Exp 6 Sample 2



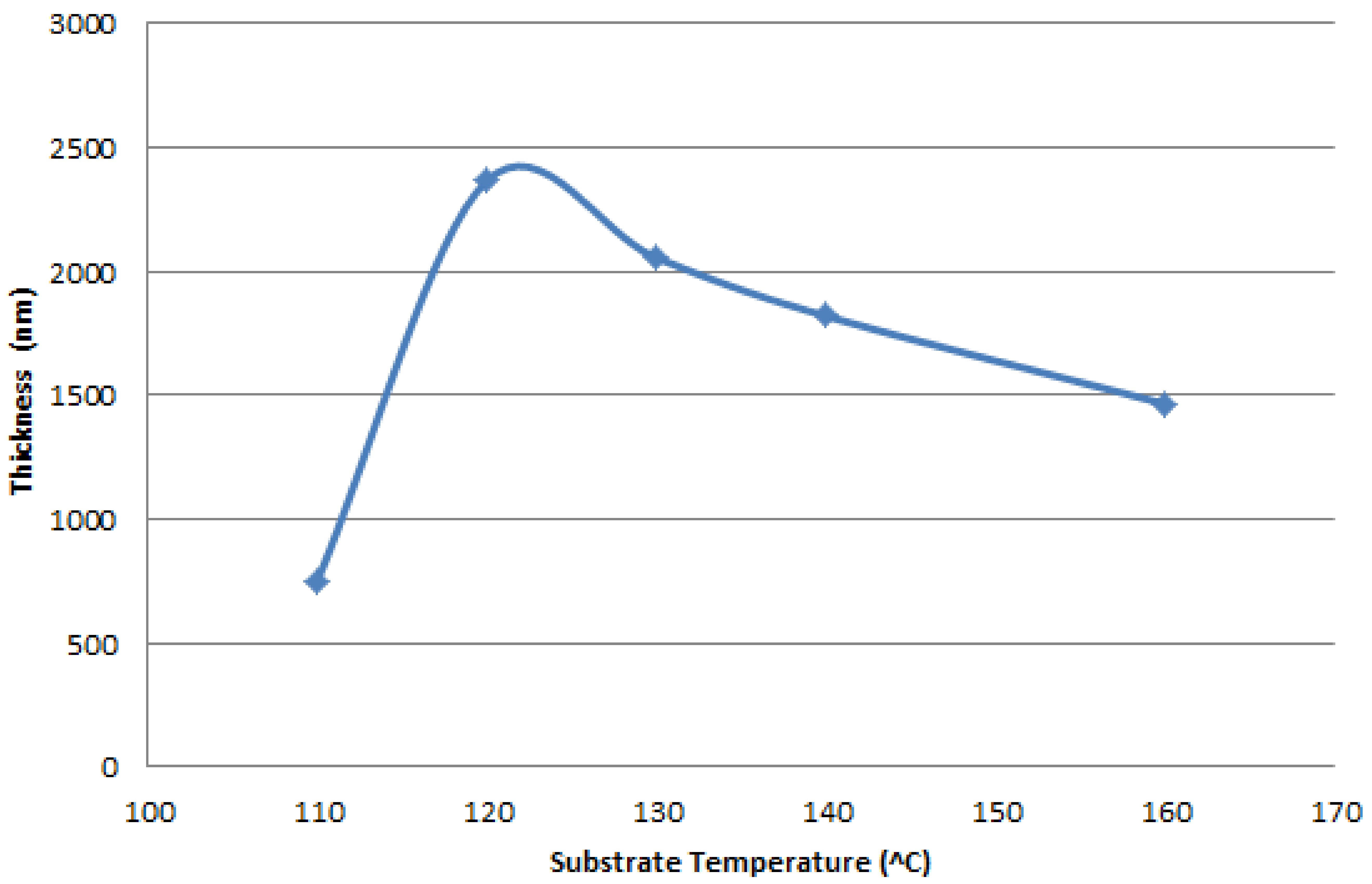
Exp 4 Sample 1



Thickness Calculations

Experiment No.	Substrate Temperature (°C)	Evaporation Temperature (°C)	Deposition Time (min)	Film Thickness (nm)
1	150	820-830	20	1521,8
4	120	830-850	16	2364,5
5	130	830-850	15	2055,8
6	140	830-850	15	1820,8
7	160	830-850	20	1465,6
8	110	830-850	15	746,5

For Exp. No. 4, 5, 6, 7, 8



Absorbtion Edges Calculations

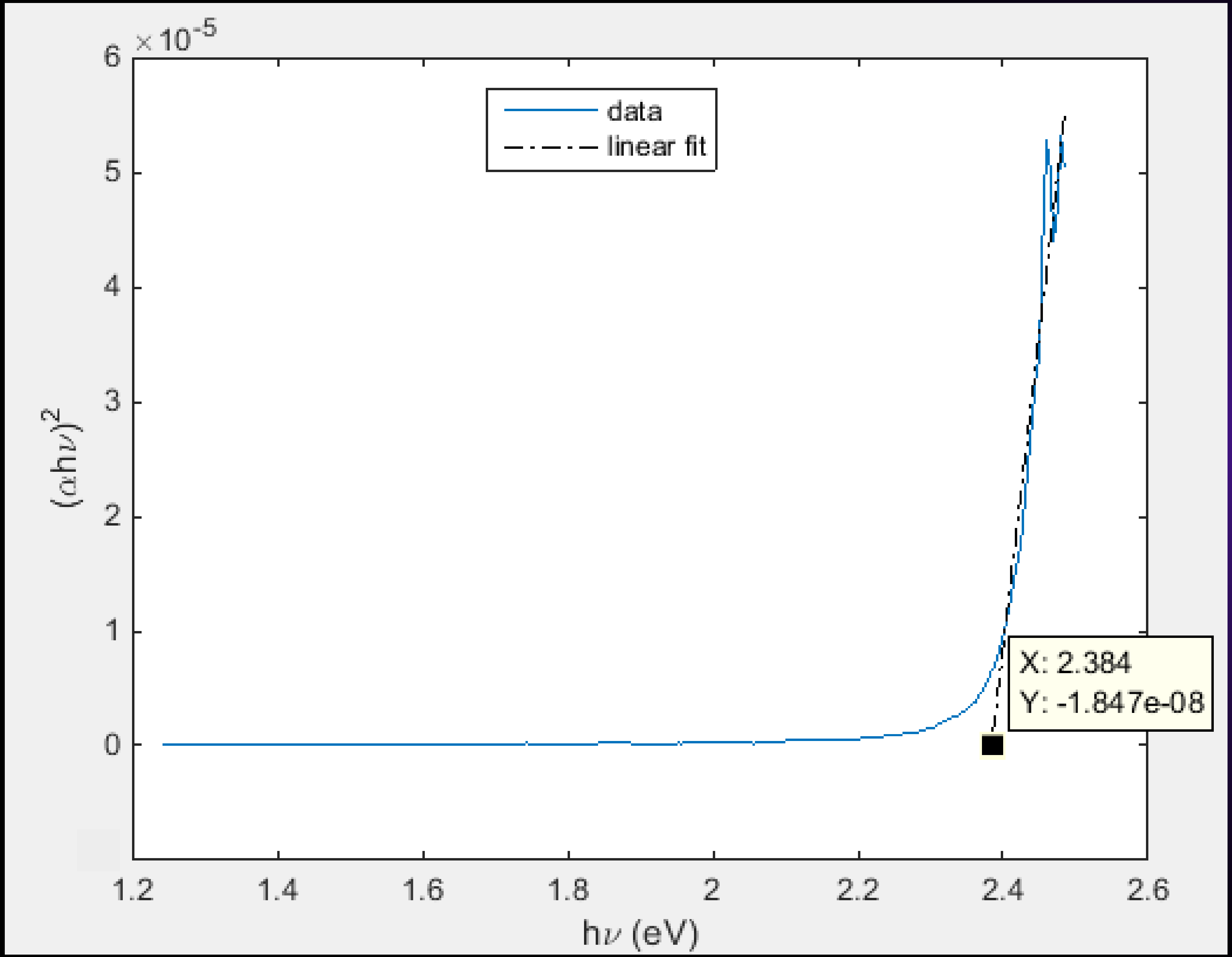
$$T = e^{-\alpha d}$$

$$(\alpha h\nu)^{\frac{1}{n}} = A(h\nu - E_g)$$

n = ½ for direct

n=2 for indirect

transitions



Absorbtion Edges Calculations

Experiment No.	Film Thickness (nm)	Band Gap Energy (eV)
1	1521,8	2,33
4	2364,5	2,37
5	2055,8	2,39
6	1820,8	2,38
7	1465,6	2,36
8	746,5	2,33

Summary

- TMM allows one to take into account the effects of structural features and equipment characteristics such as scatterring mechanisms, spectrometer resolution, noises and so on and also inclusion of various physical models
- Ranges of Measured Thicknesses
  - for metal films ~7-50 nm
  - for dielectric films ~ up to 100 um
- Measurement results are used to obtain more optimized technology regimes for Thermal Vacuum Deposition Method

Thanks for Your Attention!