Optimising the thickness determination of homopolymers and diblock copolymers using optical spectral reflectance during solvent vapour annealing

INM - RUC 2019 - Master's Thesis

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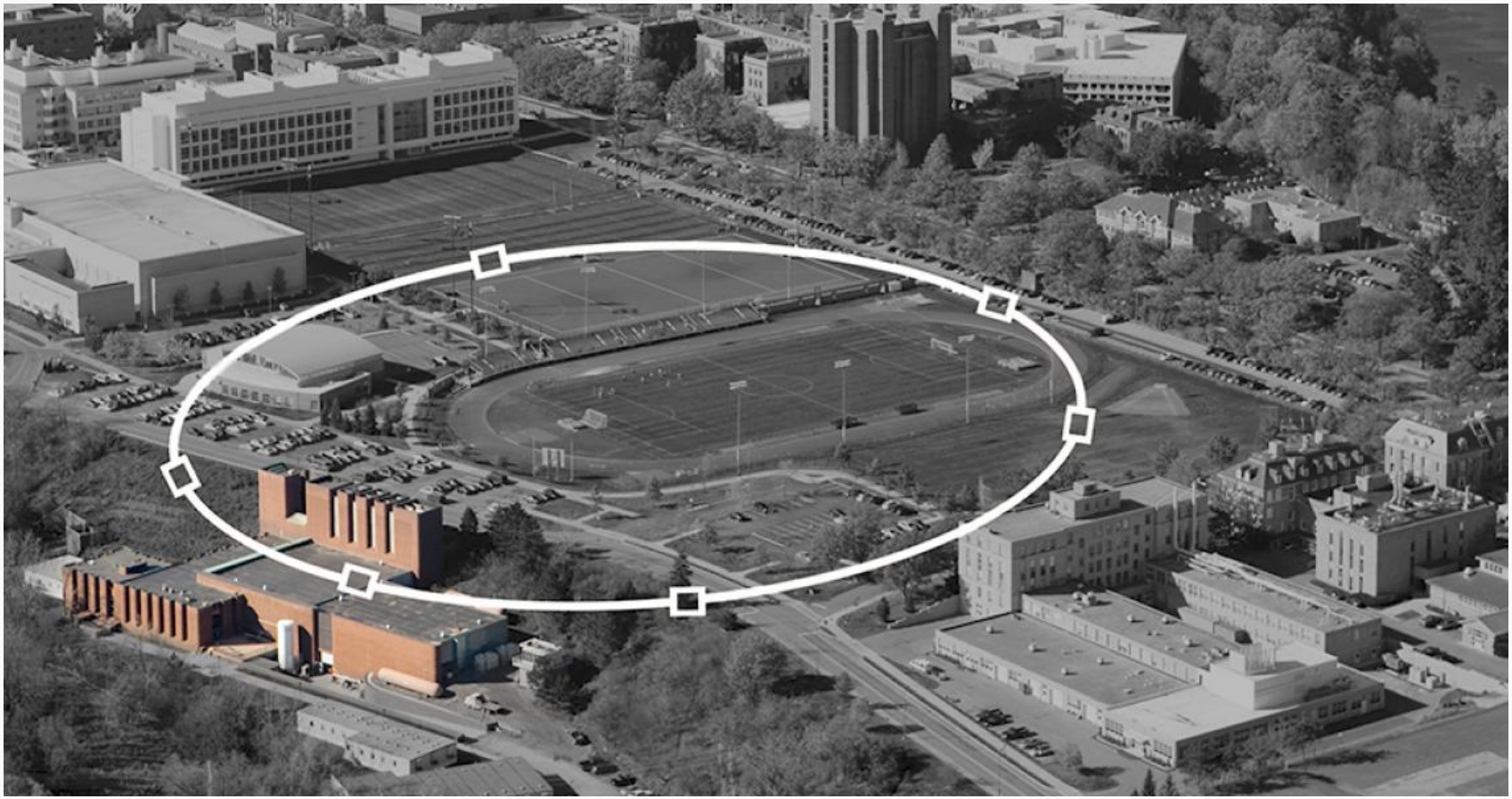
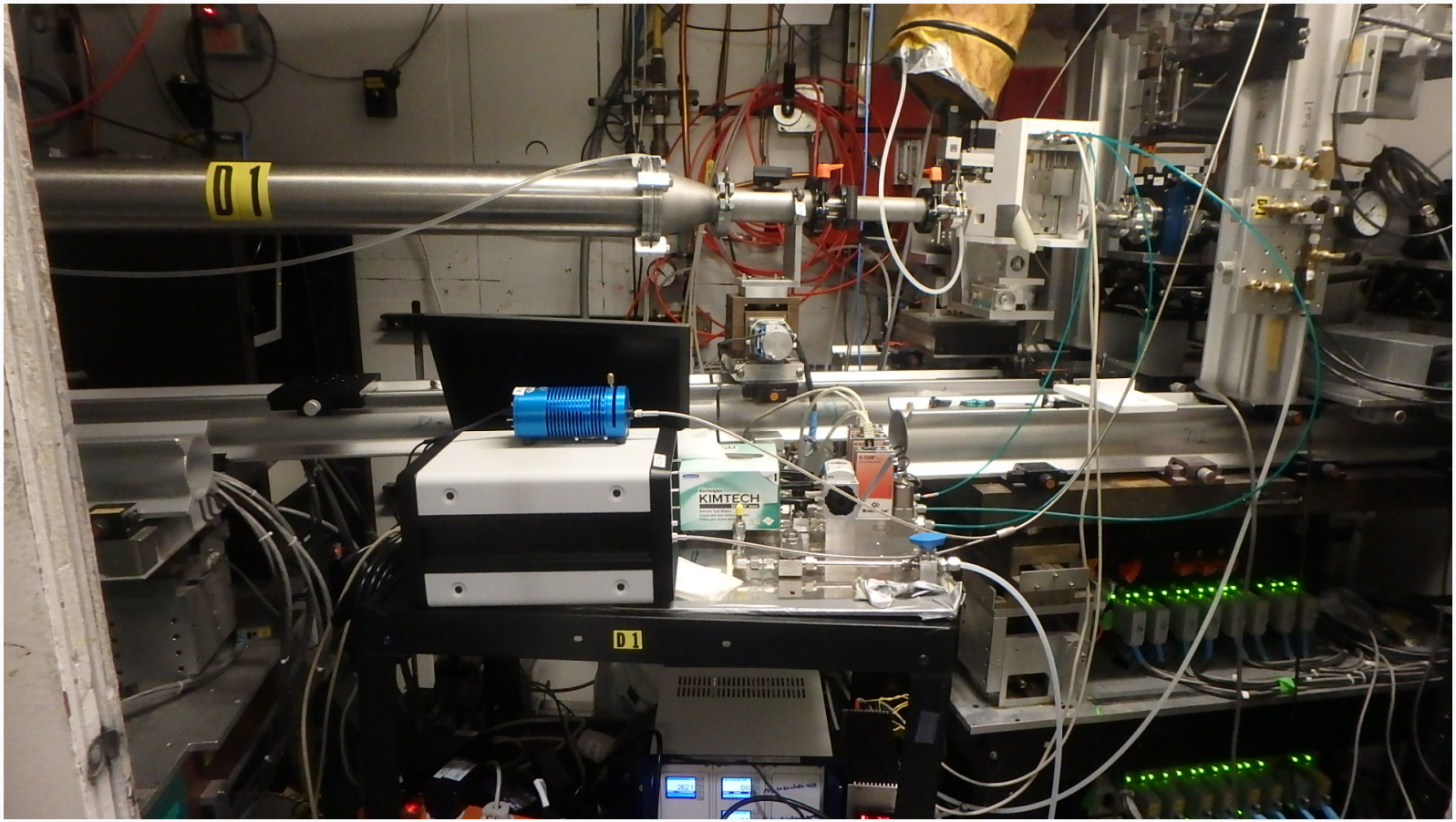
Master Thesis Background

Cornell High Energy Synchrotron Source (CHESS)



D-Line



Problems with the reflectance measurements (Nanocalc)

Figure 1: first image

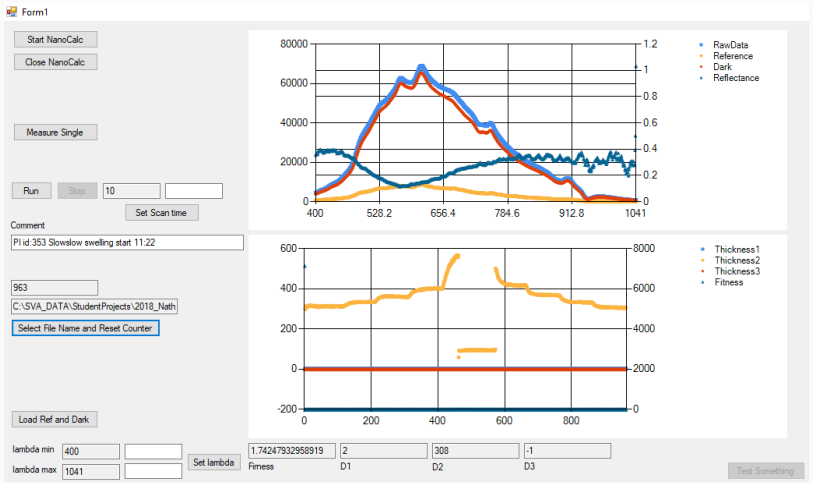


Figure 2: second image

Master Thesis Problem Formulation

Problem Formulation

What are the advantages and limitations when using optical spectral reflectance for determining the thickness of thin polymer films during solvent vapour annealing?

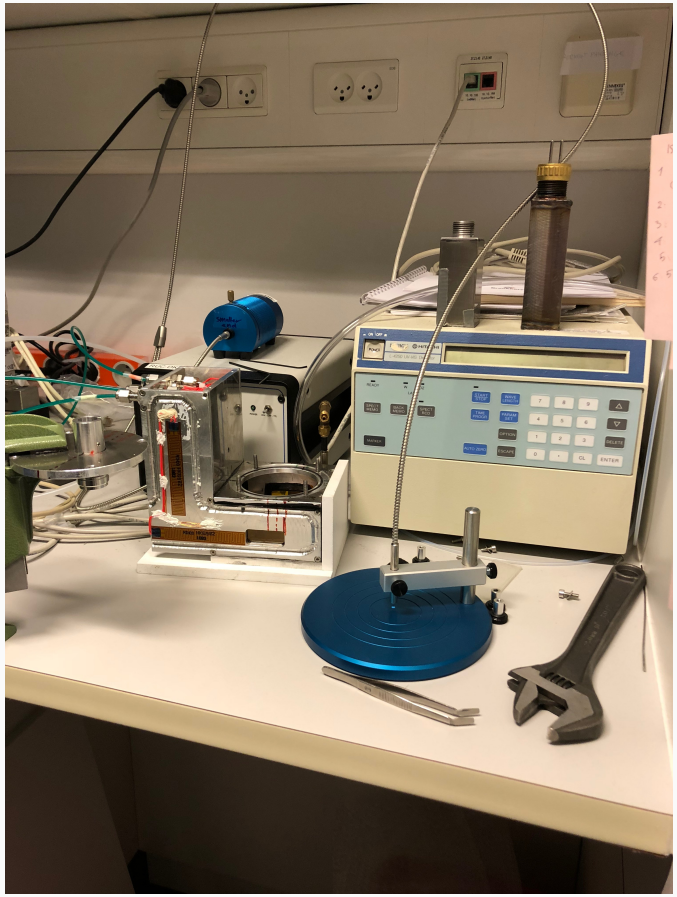
What is the optimal modelling and fitting method for the optical spectral reflectance measurements and thickness determination of the homopolymers, polystyrene and polyisoprene thin films during solvent vapour annealing?

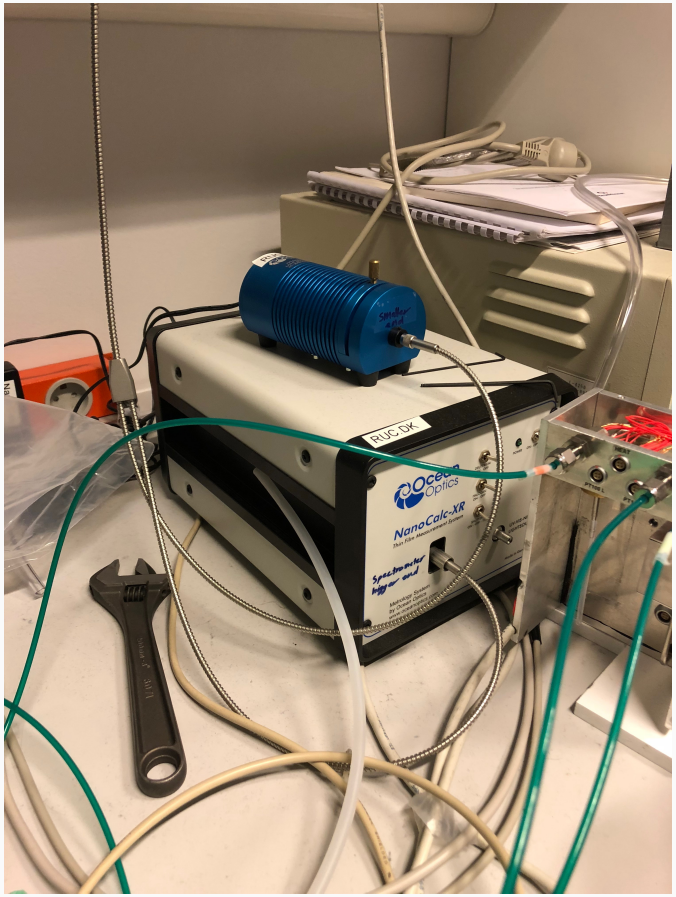
Can the same thickness determination be used on thin films with a horizontal nano scale structure such as the diblock-copolymer Polystyrene-b-Polyisoprene?

Experimental Setup, polymers and model

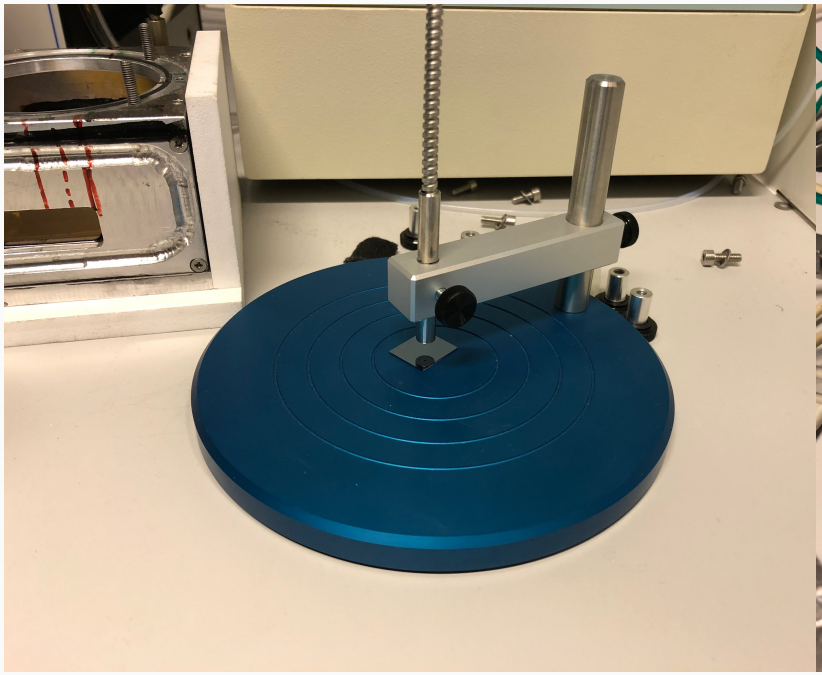
Experimental Components

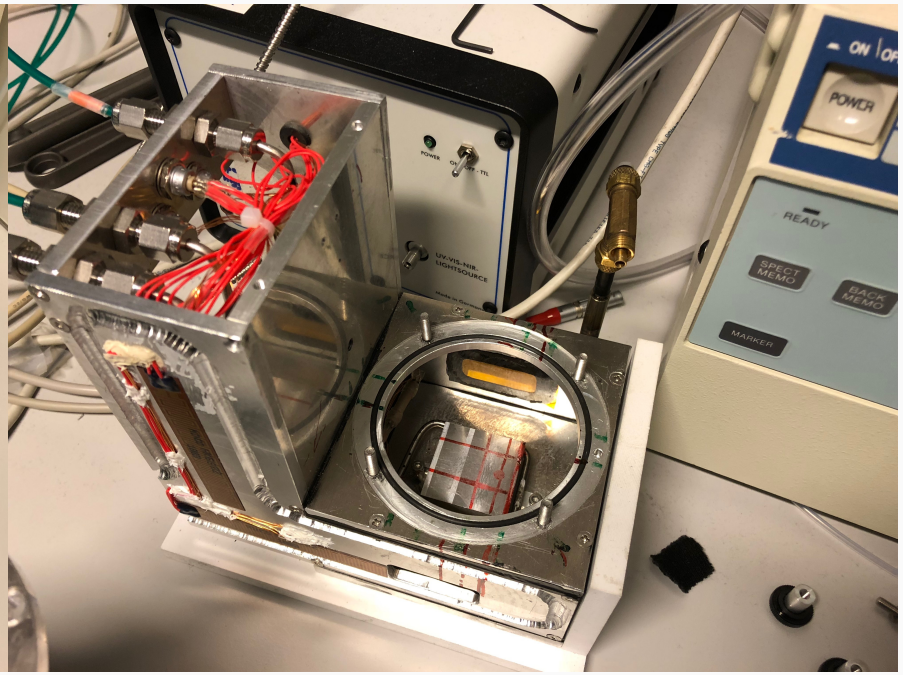
NanoCalc XR, Halogen Light Source, Test Chamber and Single Point Stage



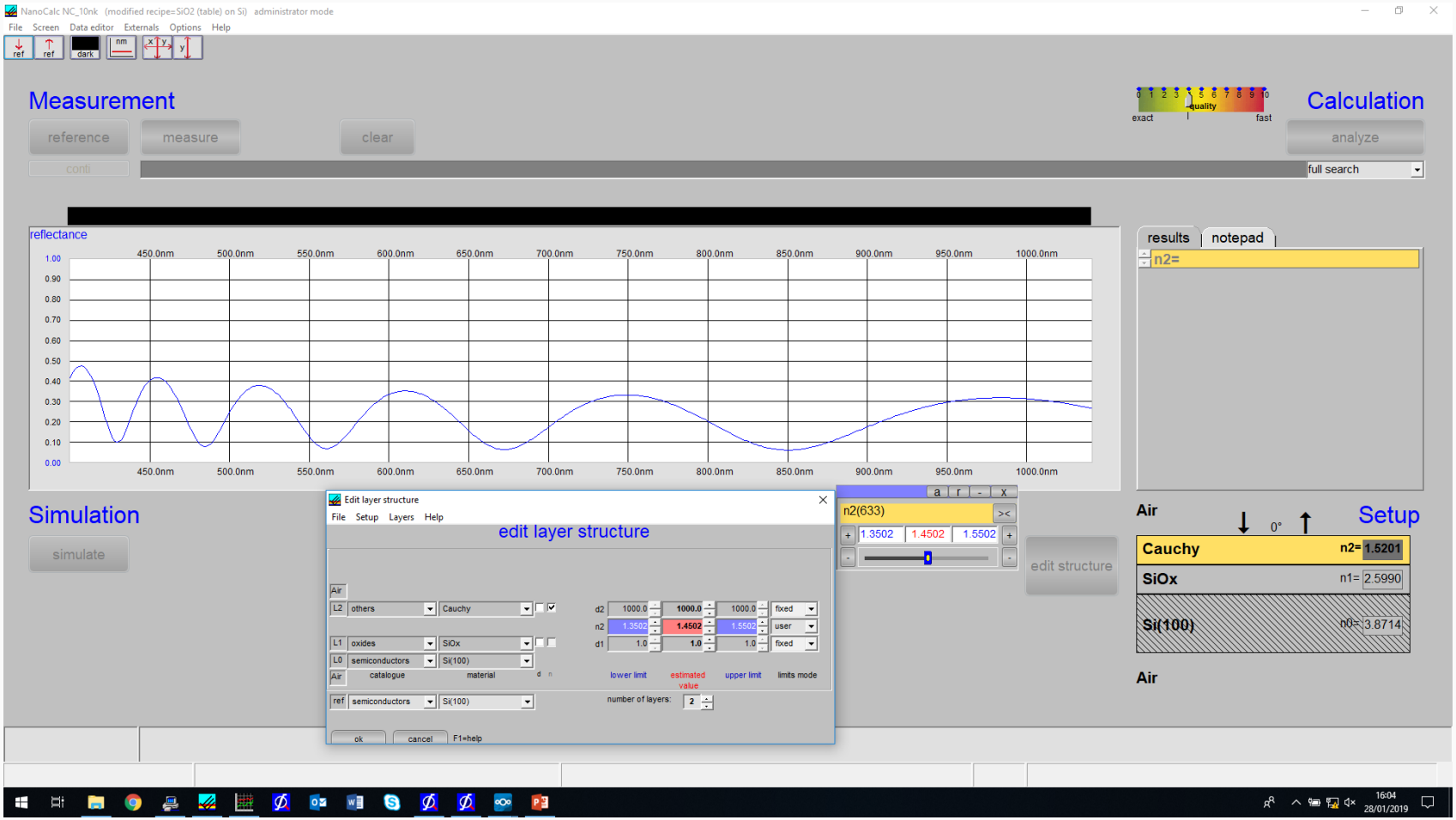


Experimental Components Cont.





NanoCalc Software



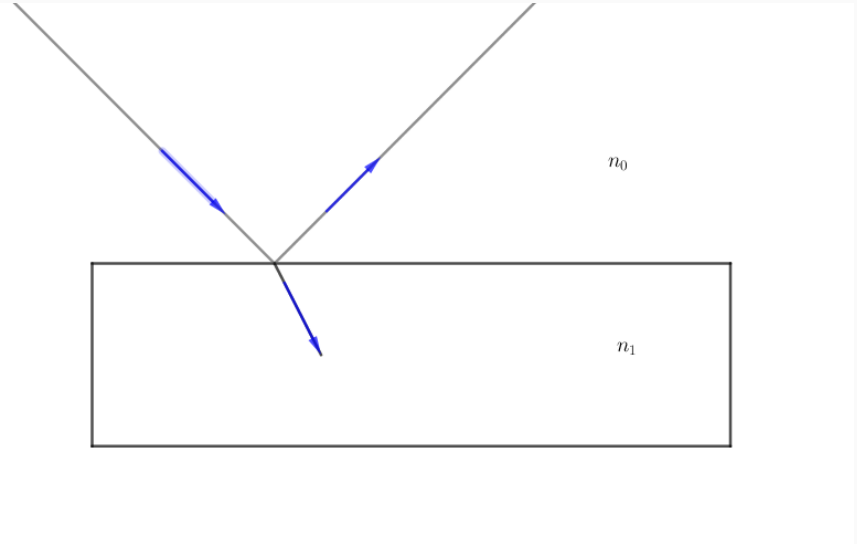
$$Reflectance = \frac{Meas - Dark}{Ref} \cdot R_{sub}$$

Preliminary Models

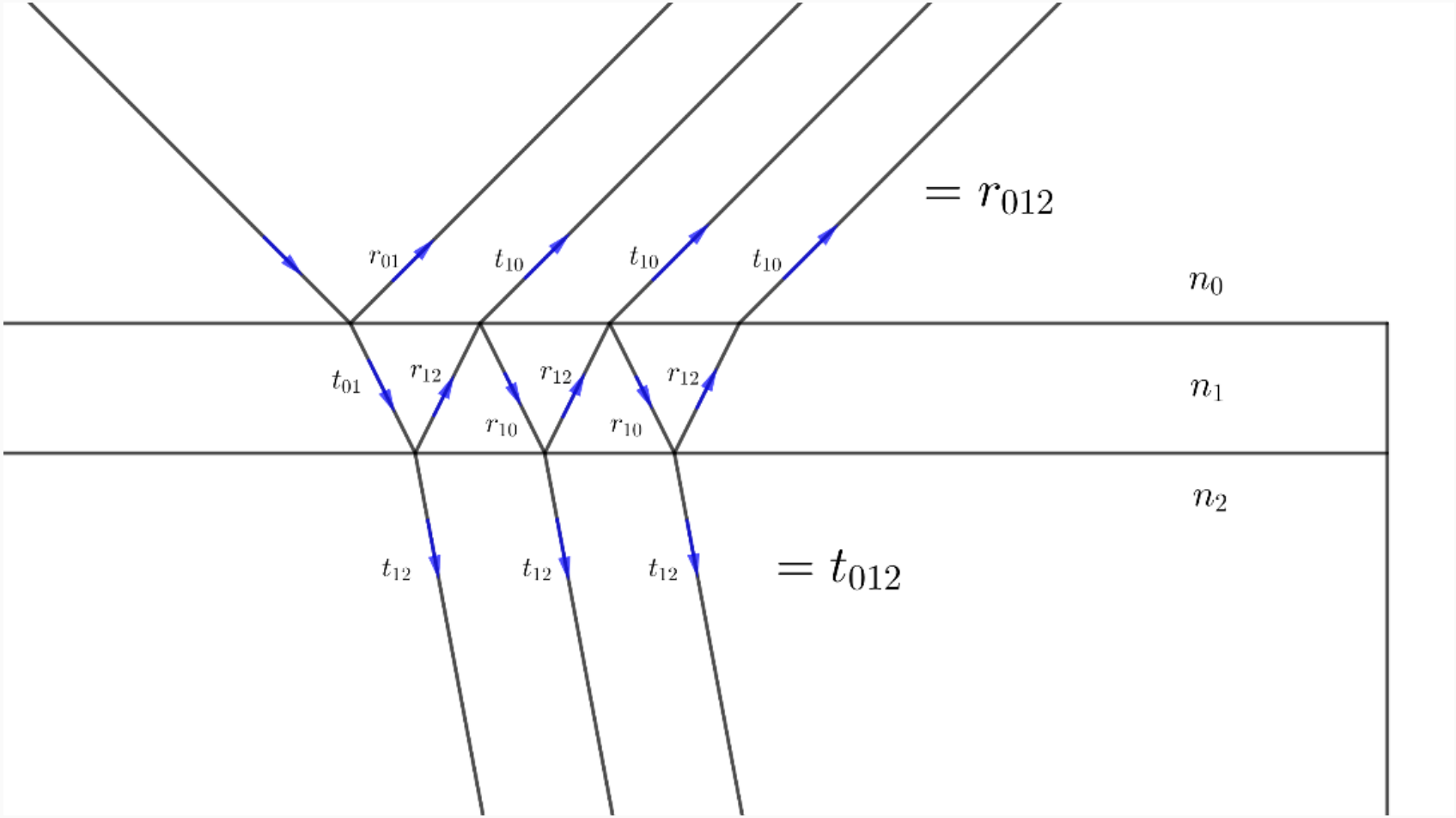
Fresnel Equations - Substrate

$$r_p = \frac{E_{r,p}}{E_{i,p}} = \frac{n_t \cos(\theta_i) - n_i \cos(\theta_t)}{n_i \cos(\theta_t) + n_t \cos(\theta_i)}$$

$$R_p = \mid r_p \mid^2$$



Fresnel Equations - One layer



$$r_{012} = r_{01} + t_{01}t_{10}r_{12}\exp(-i2\beta) + t_{01}t_{10}r_{10}r_{12}^2\exp(-i4\beta) + t_{01}t_{10}r_{10}^2r_{12}^3\exp(-i6\beta) + \cdots$$

Fresnel Equations - One layer

$$r_{012} = \frac{r_{01} + r_{12}\exp(-i2\beta)}{1 + r_{01}r_{12}\exp(-i2\beta)}$$

$$\beta = \frac{2\pi d_1}{\lambda} n_1 \cos(\theta_1)$$

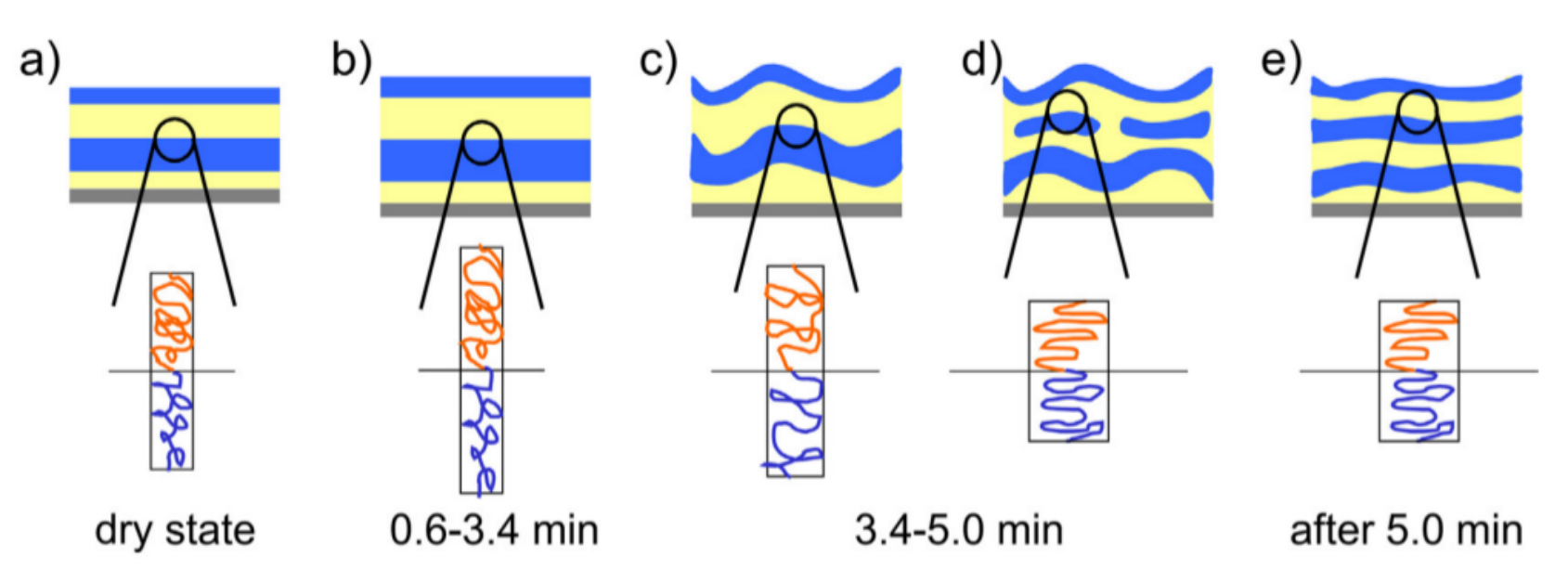
$$R_{012} = \mid r_{012} \mid^2$$

Results

Solvent Vapor Annealing of Polystyrene in Toluene

Why look at structure?

Structure in thinfilms



Structure in Nature