Understanding the reflectance of homo-polymers using White Light Spectroscopic Reflectometry

Ongoing Master Thesis

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CHESS Dec 17 and May 18

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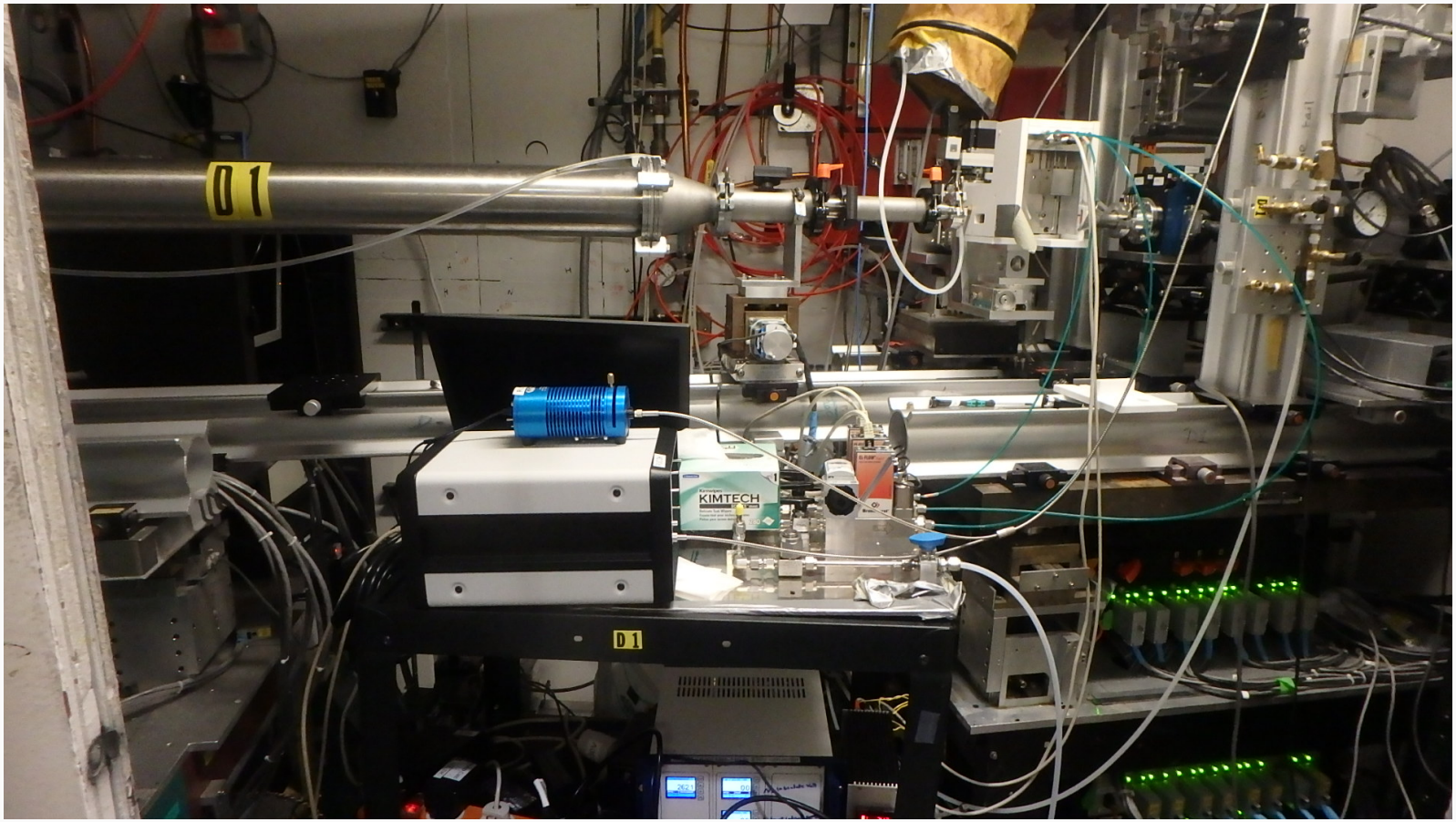

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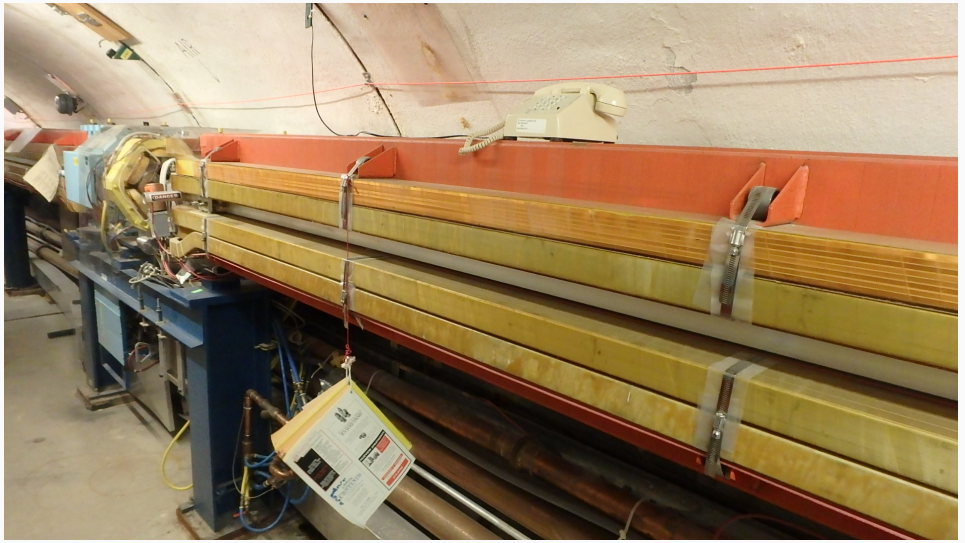
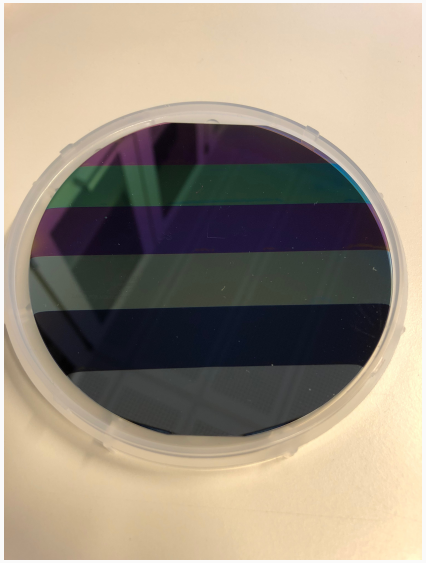


Thin Film Thickness

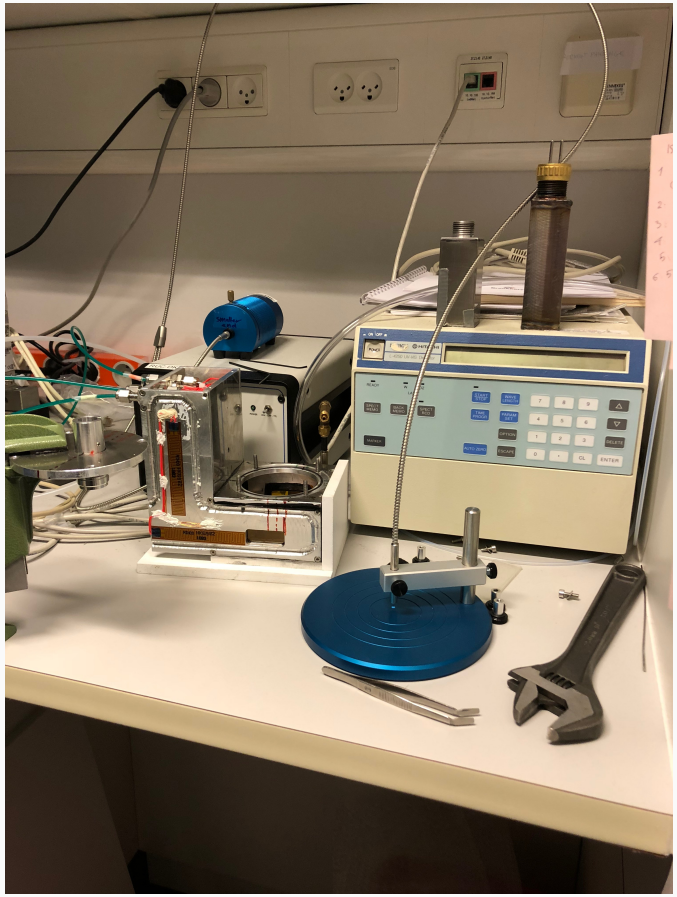
- Experimental techniques: Atomic Force Microscopy, Ellipsometry and x-ray reflectometry
- Spectroscopic Reflectometry
  - In-situ
  - Harsh environment
  - Small enough for test chamber and testing stage
- Complement GISAXS measurements

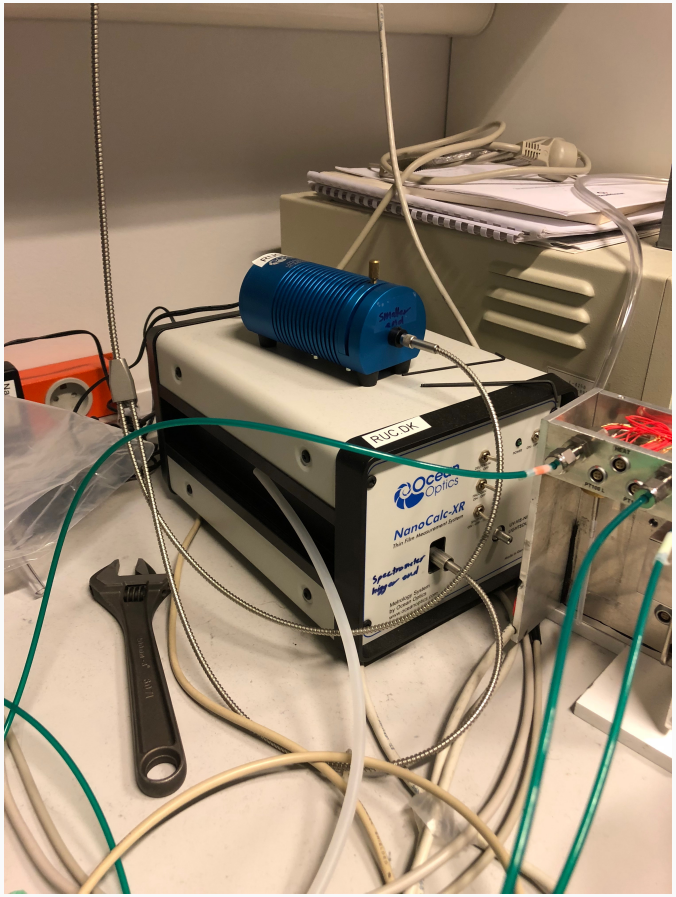


Experimental Setup

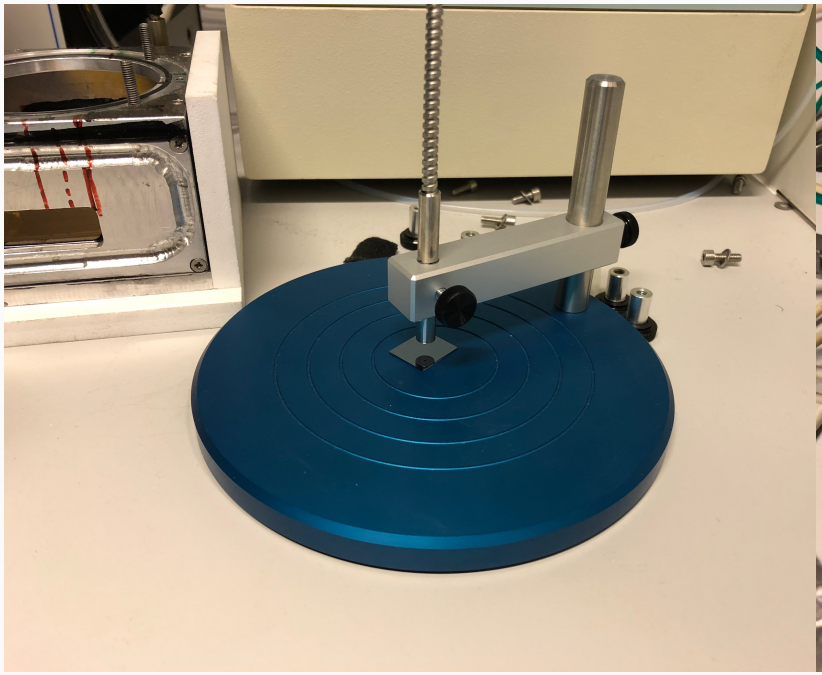
Components

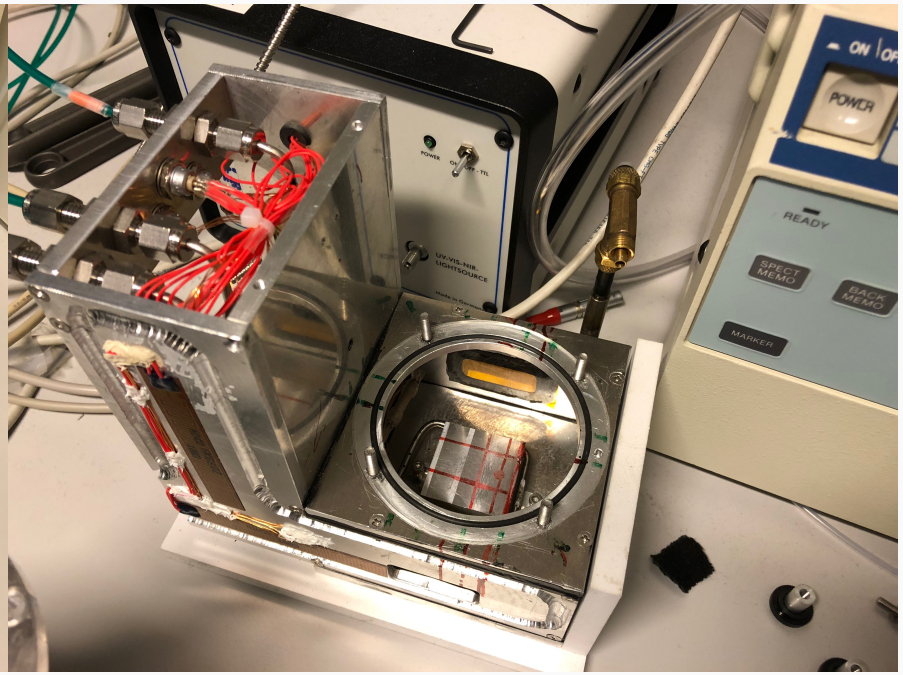
NanoCalc XR, Halogen Light Source, Test Chamber and Single Point Stage



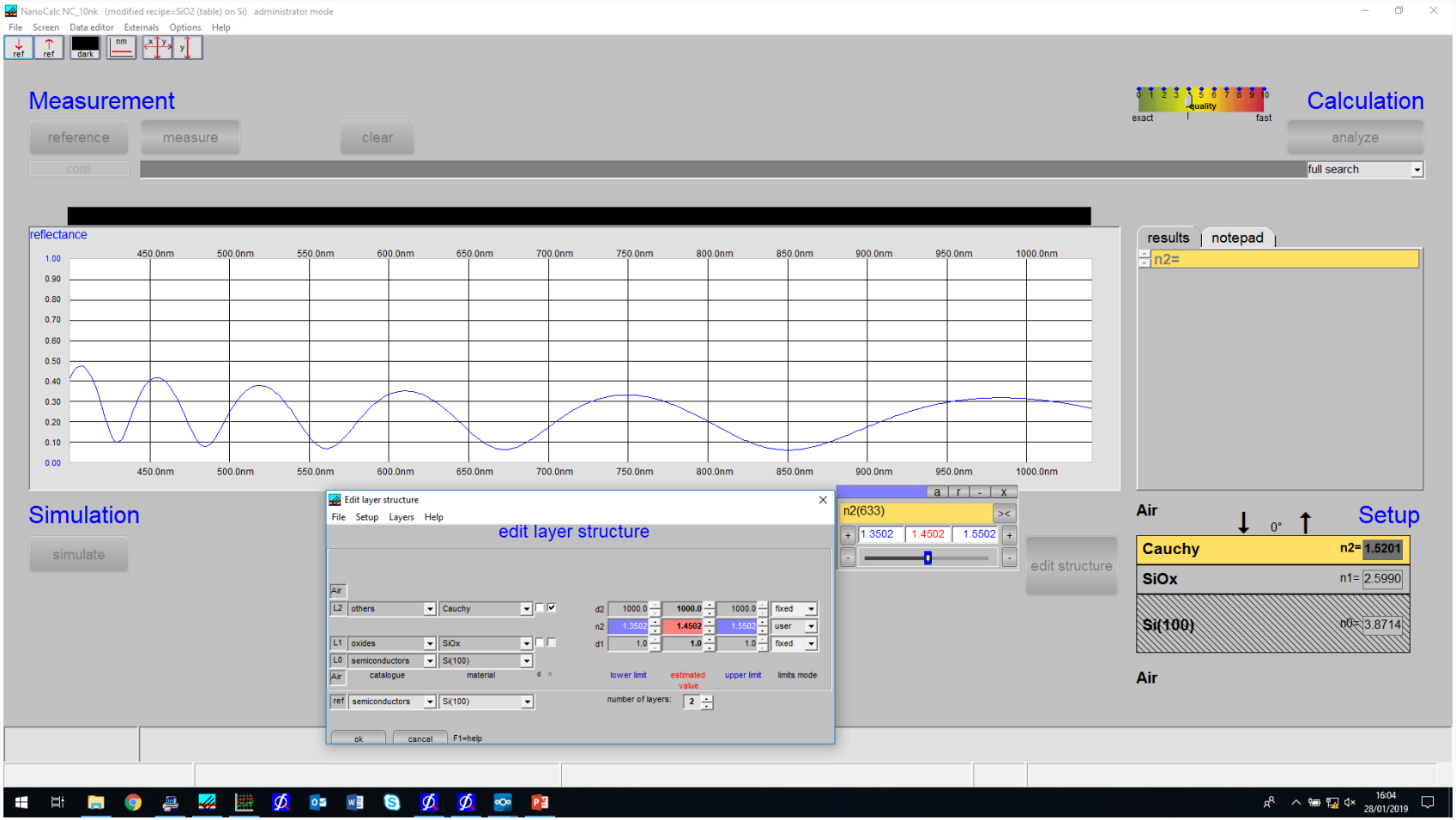


Components Cont.





NanoCalc Software



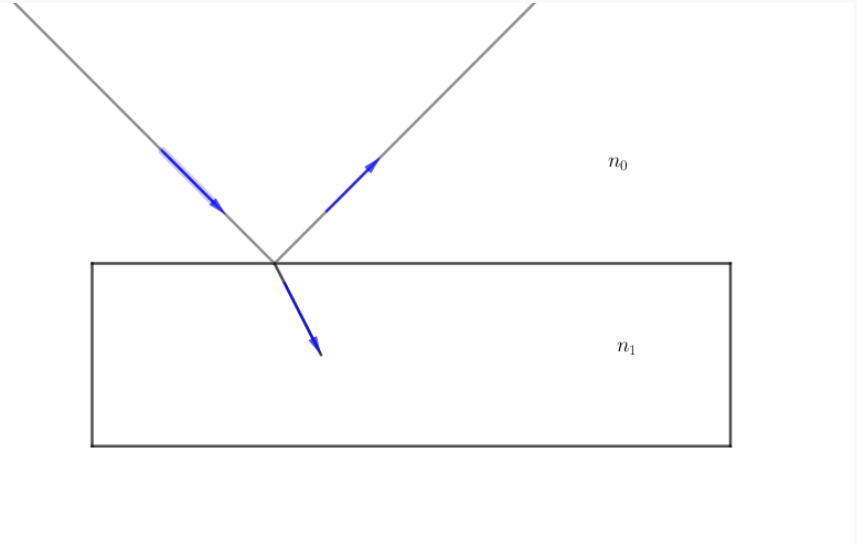
$$Reflectance = \frac{Meas - Dark}{Ref} \cdot R_{sub}$$

Preliminary Models

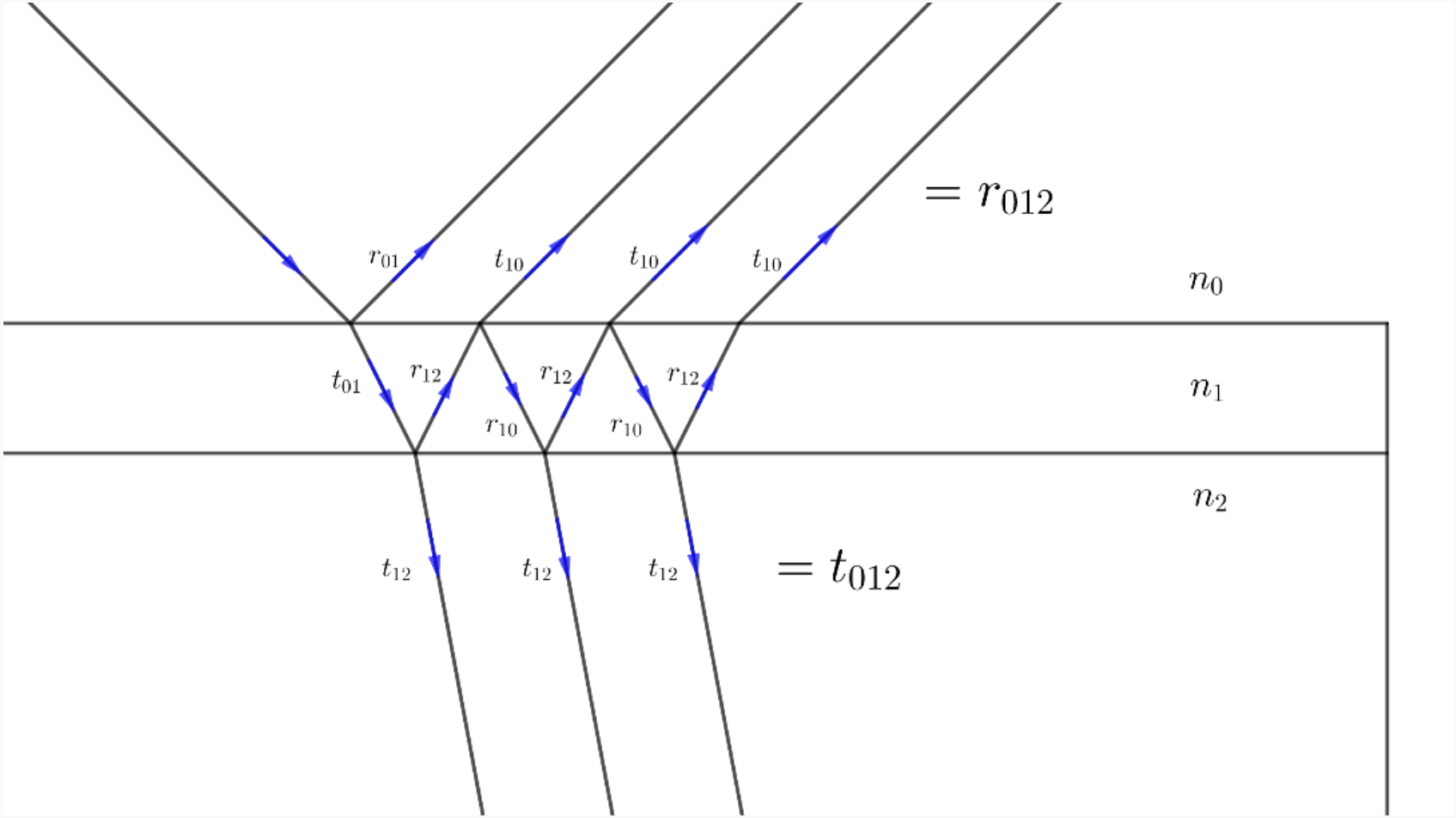
Fresnel Equations - Substrate

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

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



Fresnel Equations - One layer



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

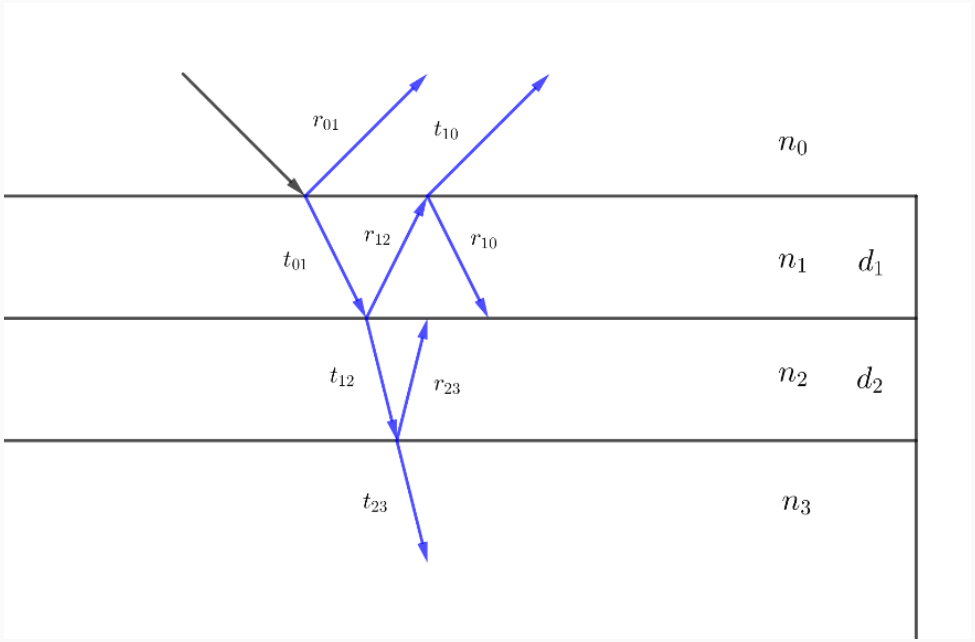
Fresnel Equations - One layer

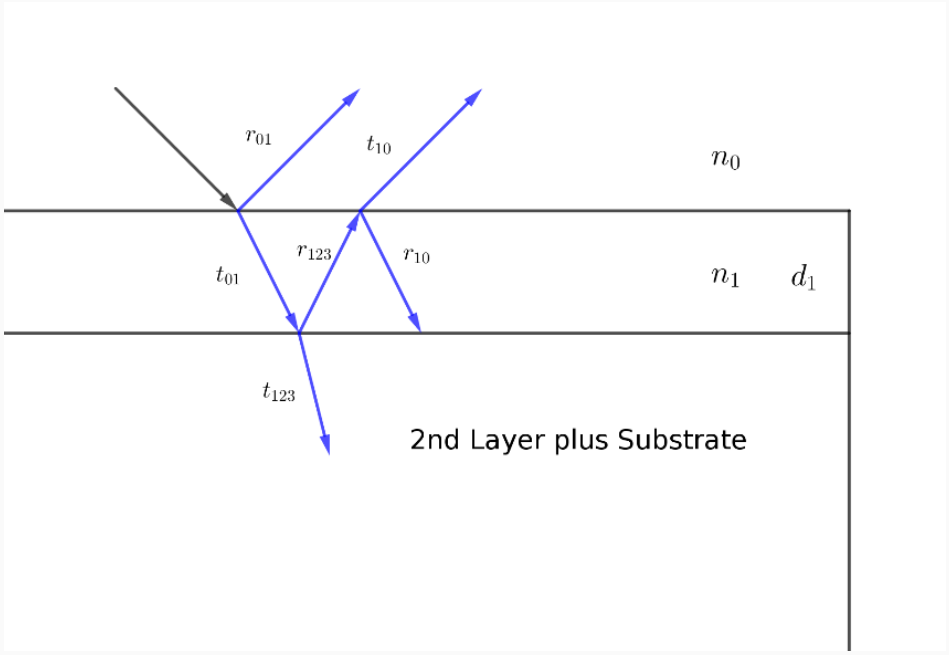
$$r_{012} = r_{01} + \frac{t_{01}\, t_{10}\, r_{12} \exp(-i2\beta)}{1 - r_{10}\, r_{12} \exp(-i2\beta)}$$

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

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

Fresnel equations - multilayers





Fresnel equations - multilayers Cont.

$$r_{123} = \frac{r_{12} + r_{23}\exp(-i2\beta_2)}{1 + r_{12}r_{23}\exp(-i2\beta_2)}$$

$$\beta = \frac{2\pi d}{\lambda} n\cos(\theta)$$

$$r_{0123} = \frac{r_{01} + r_{123}\exp(-i2\beta_1)}{1 + r_{01}r_{123}\exp(-i2\beta_1)}$$

Polymer refractive index dispersion

Cauchy empirical equation for the refractive index in the visible light range.

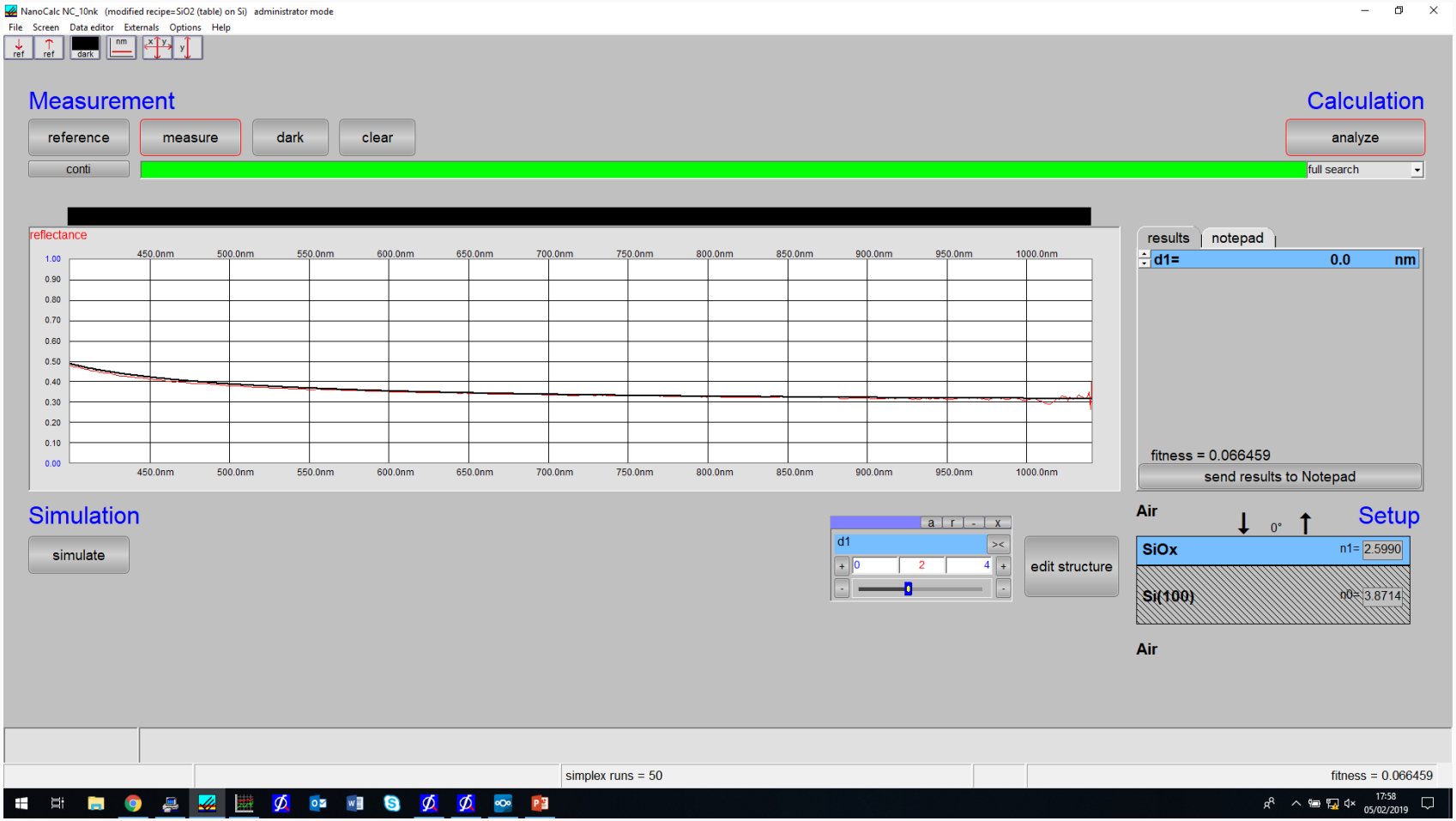
$$n(\lambda) = A + \frac{B}{\lambda^2} + \frac{C}{\lambda^4}$$

These constants can be found using ellipsometry.

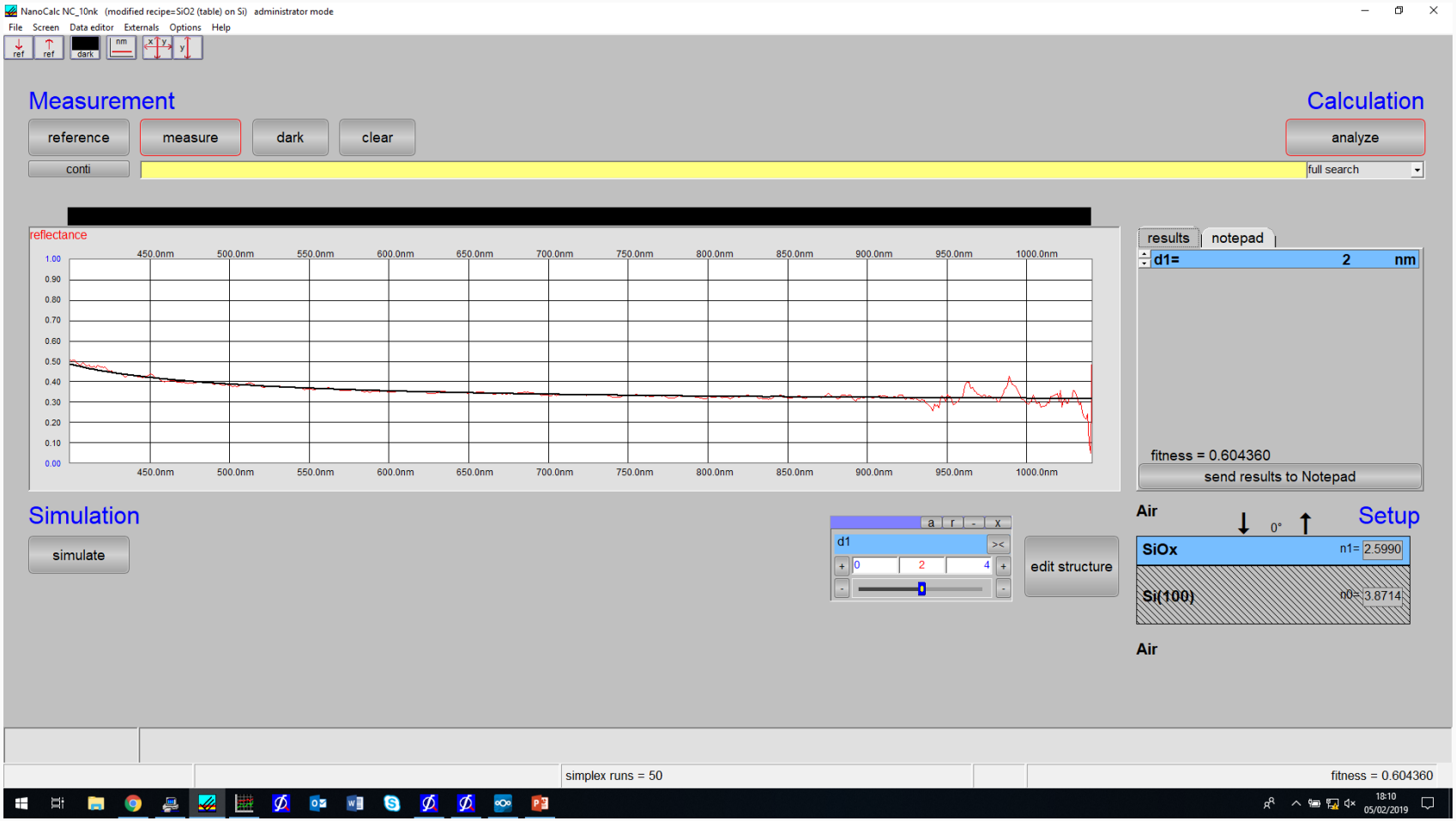
Which dispersion to use? Can Cauchy be used for more exotic polymers?

Preliminary Results

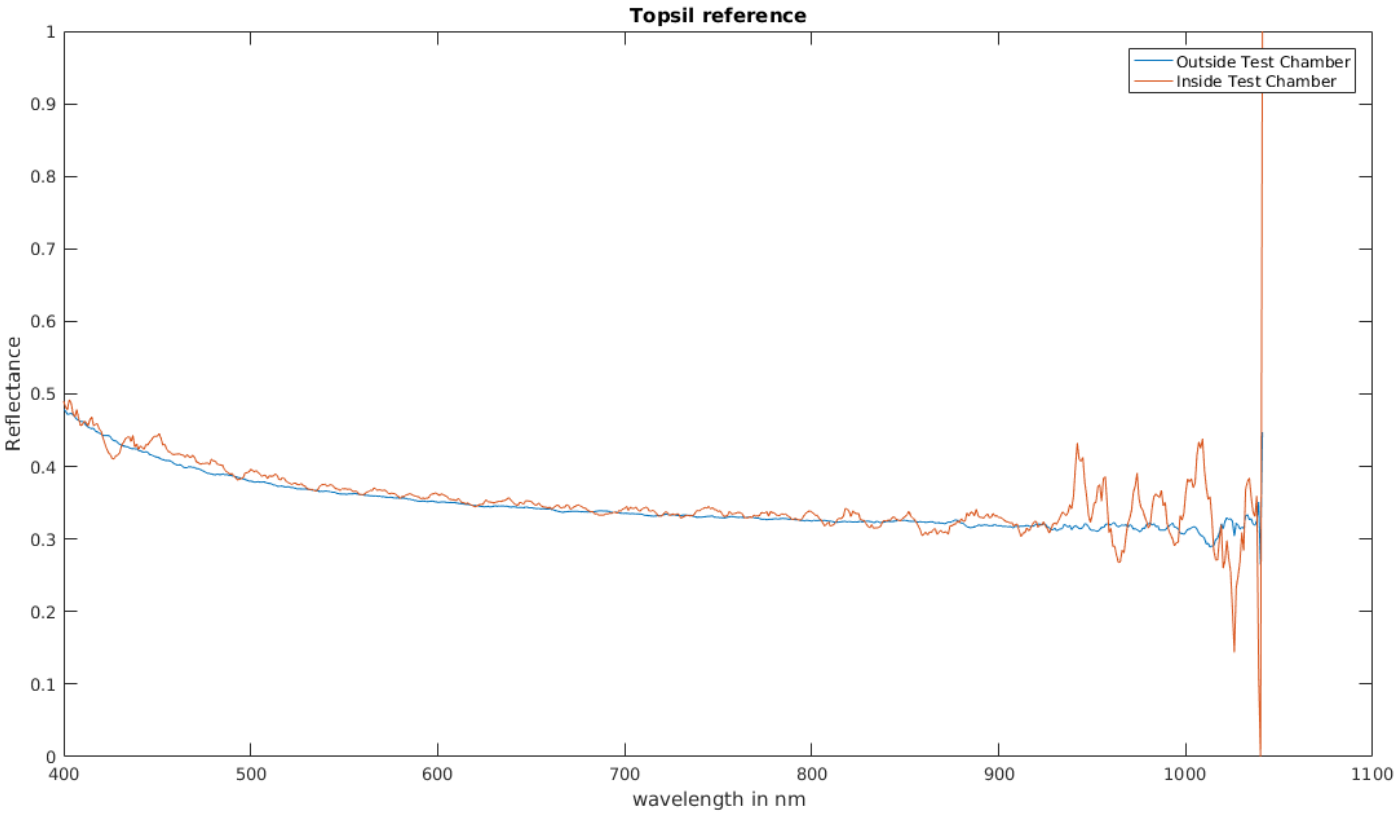
Substrate Results



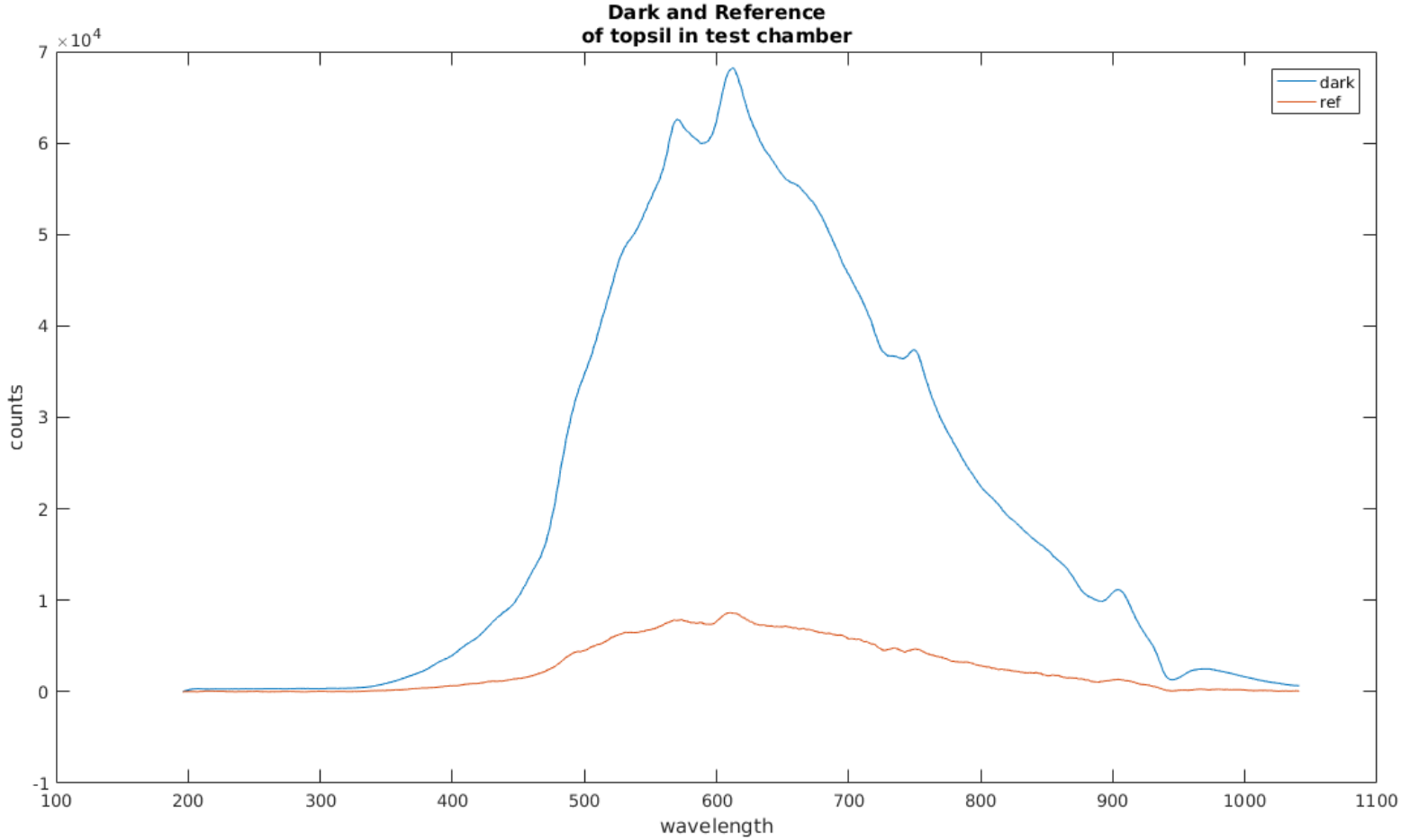
Substrate Results



Substrate Results



Dark and Ref of Topsil in the test chamber



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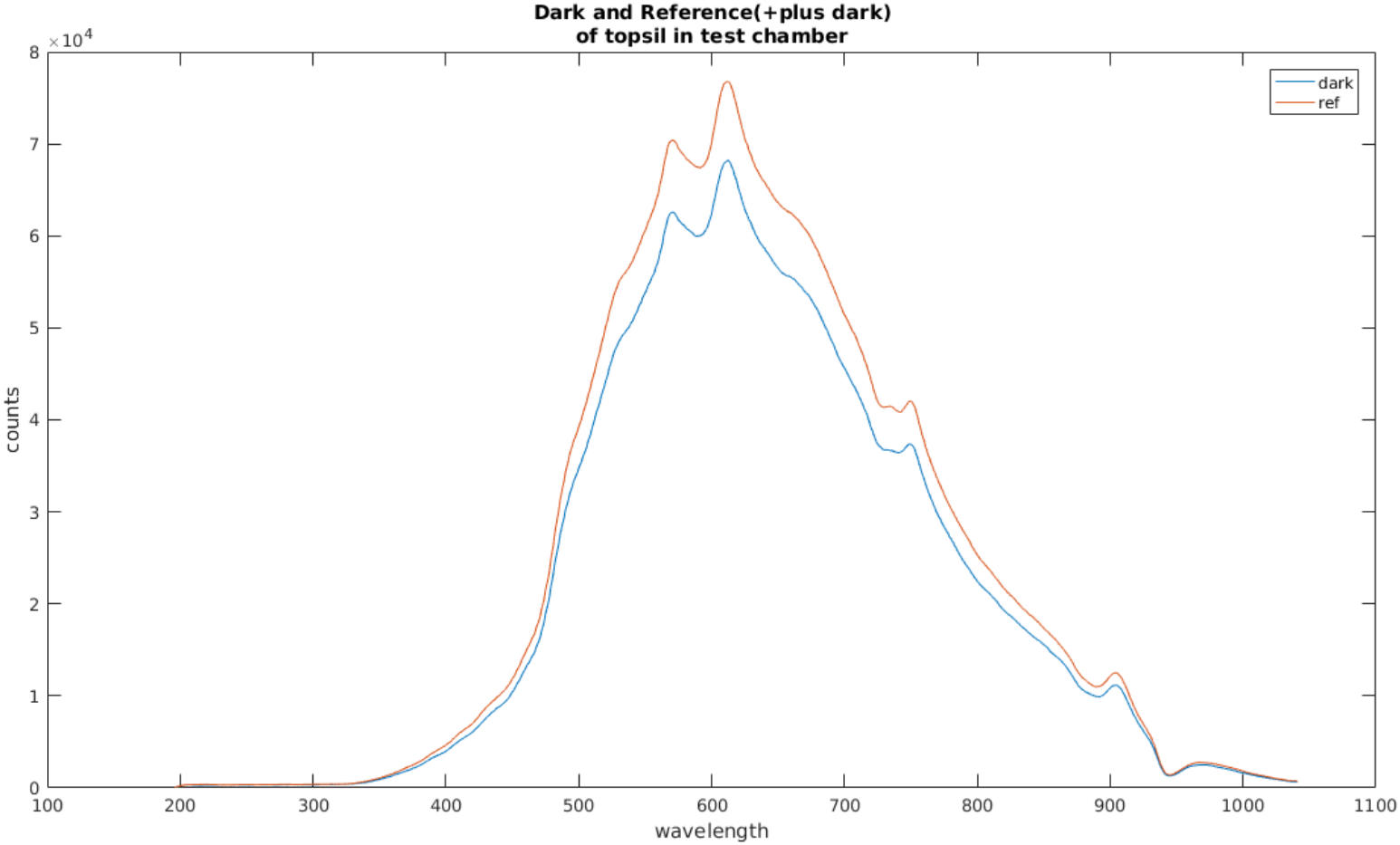
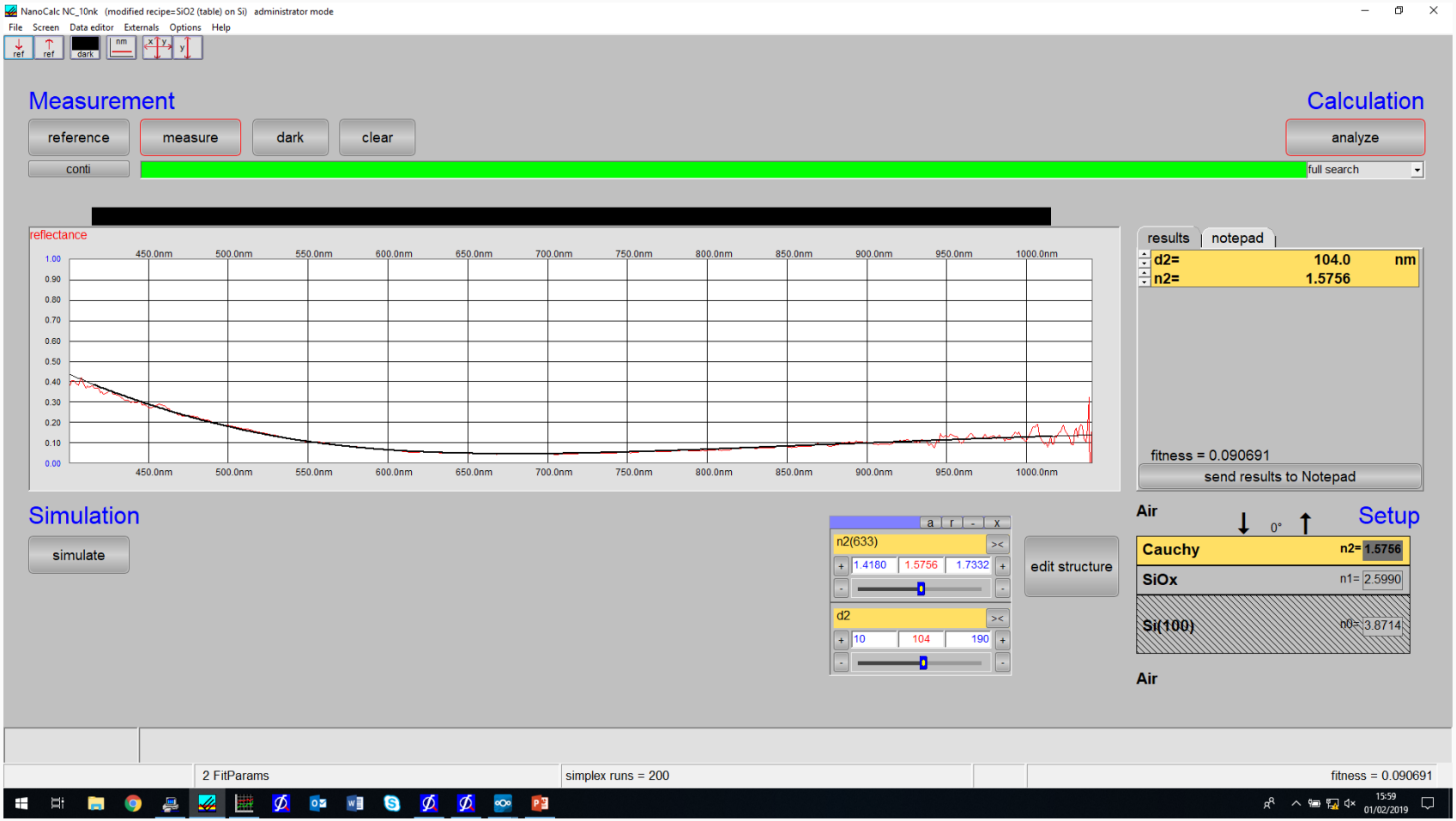
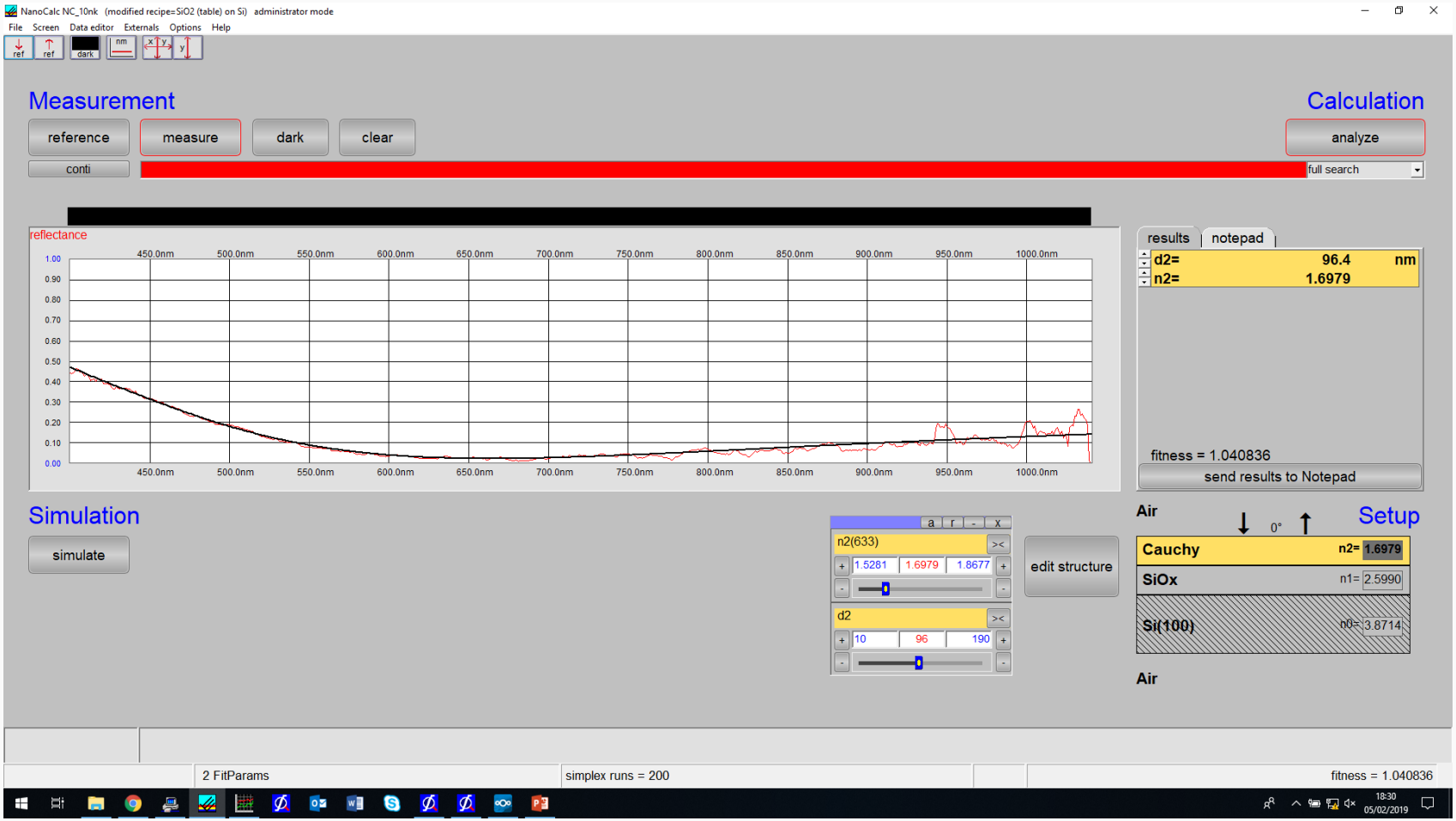


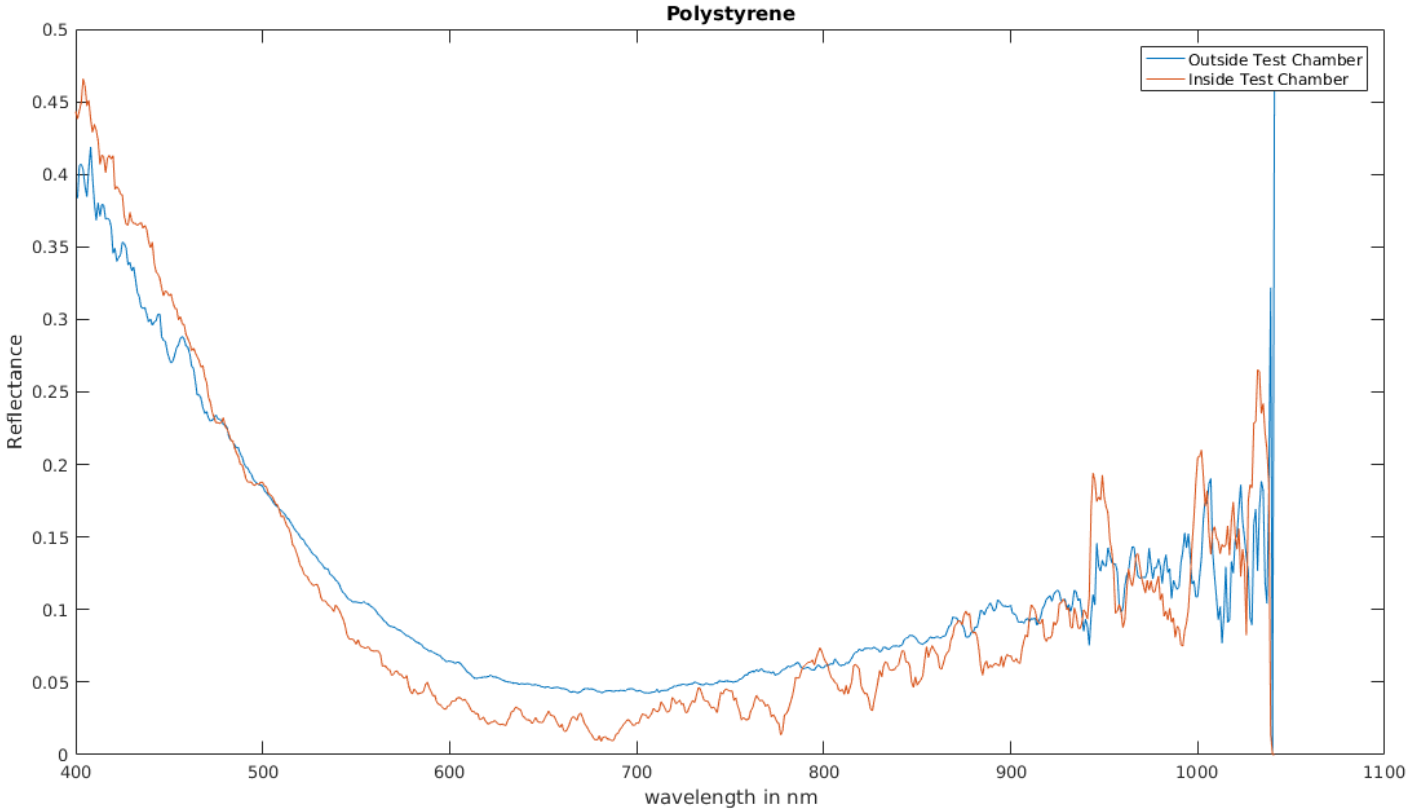
Polystyrene Results



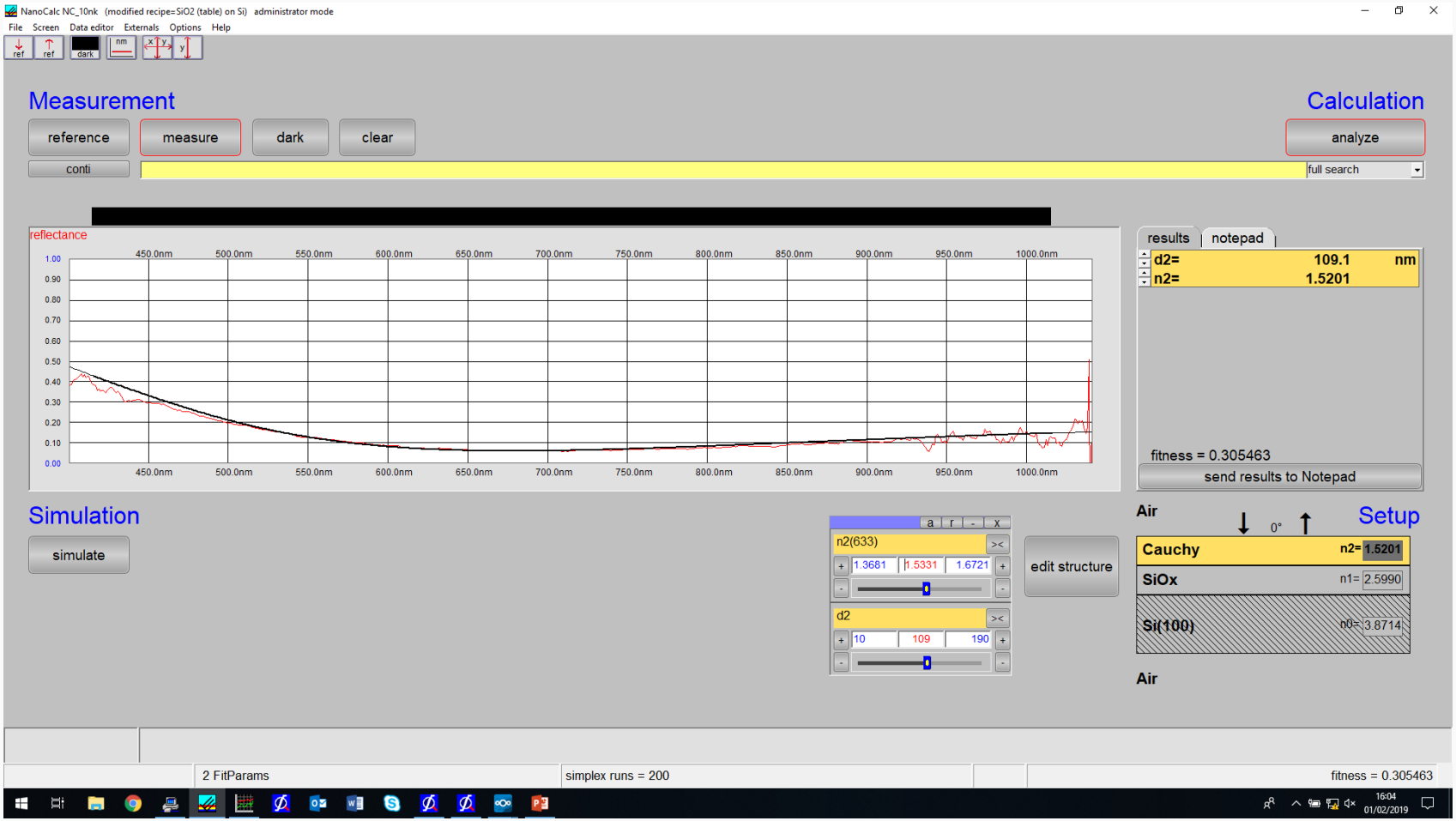
Polystyrene Results



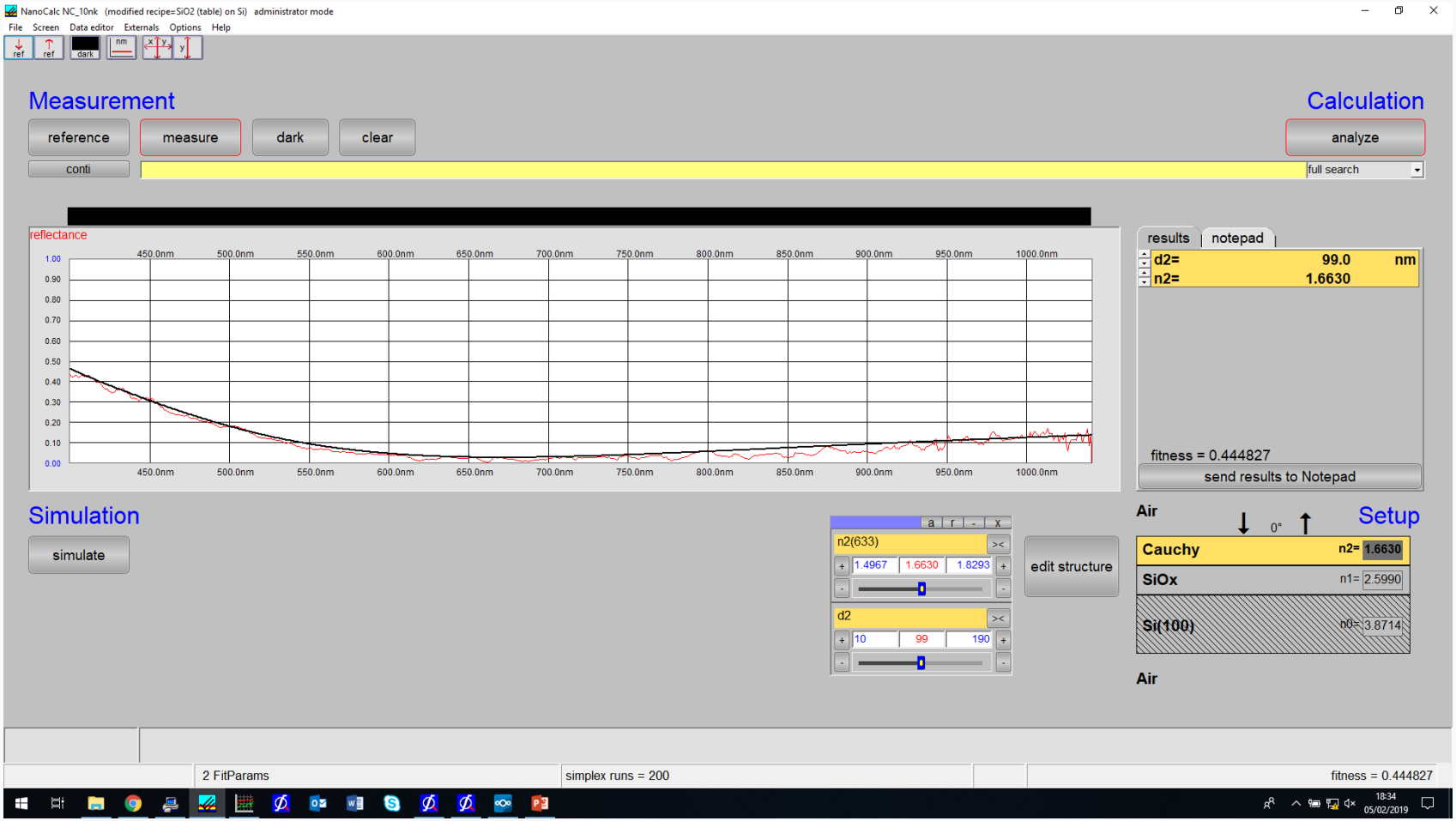
Polystyrene Results



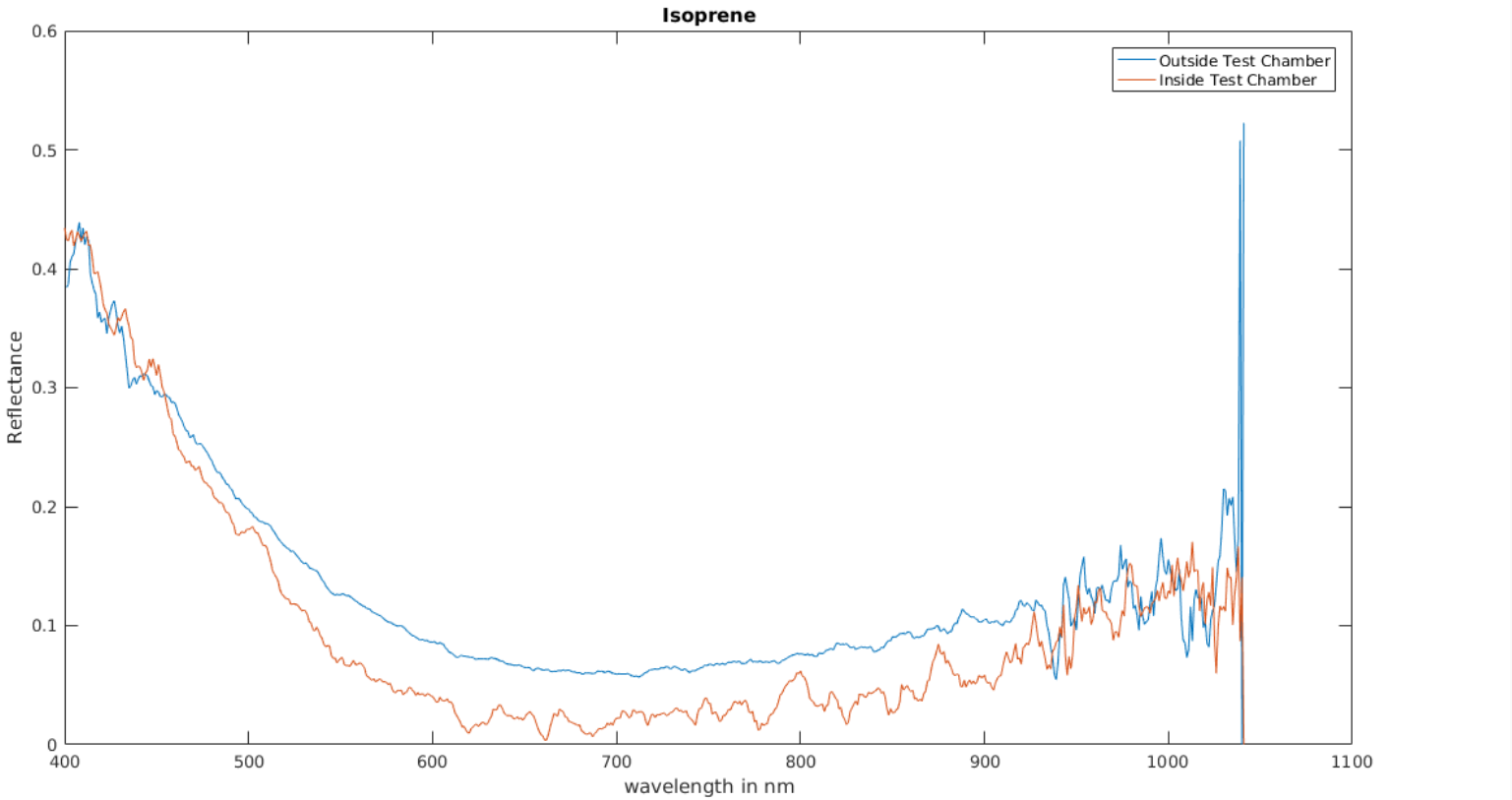
Isoprene Results



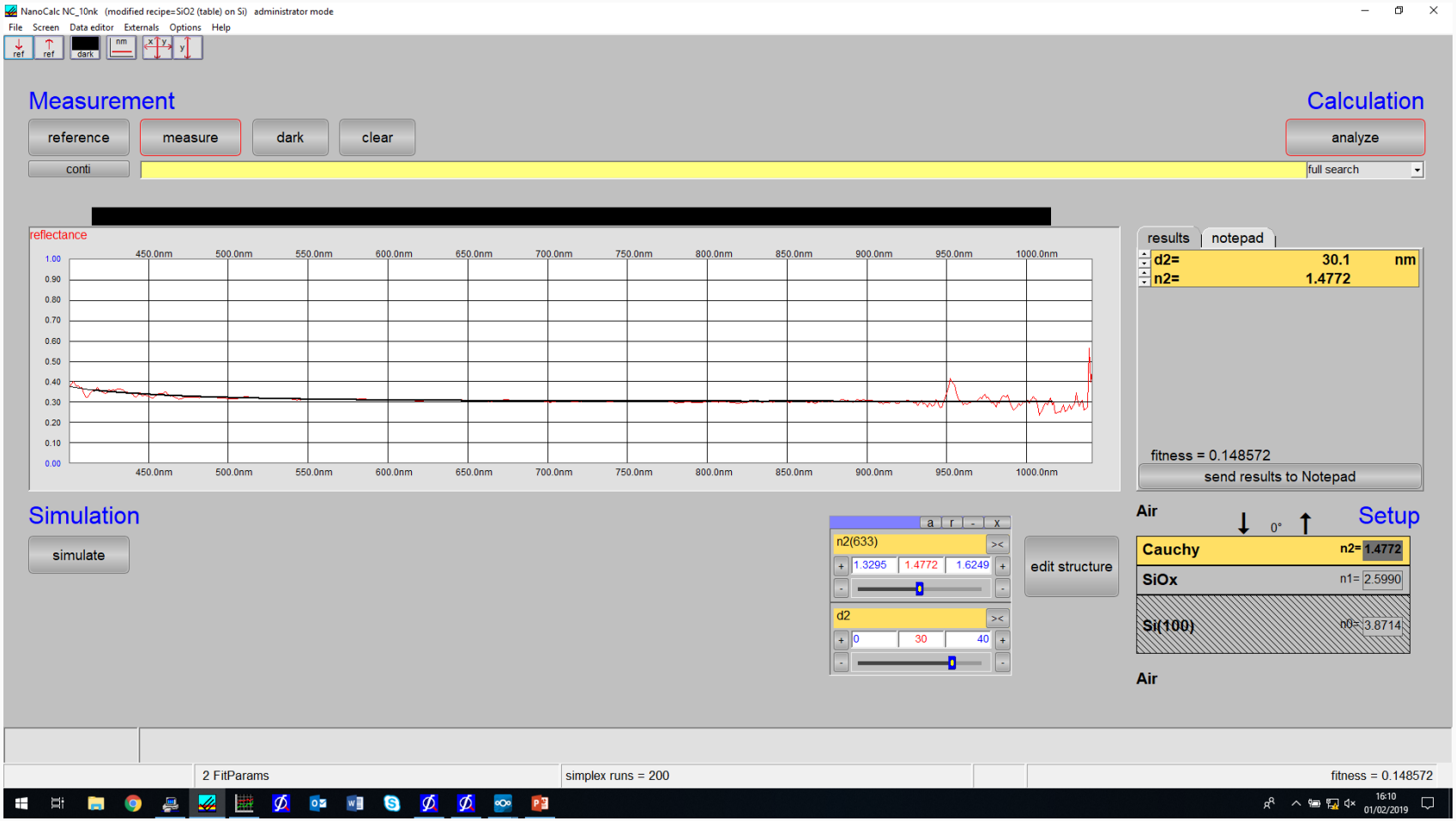
Isoprene Results



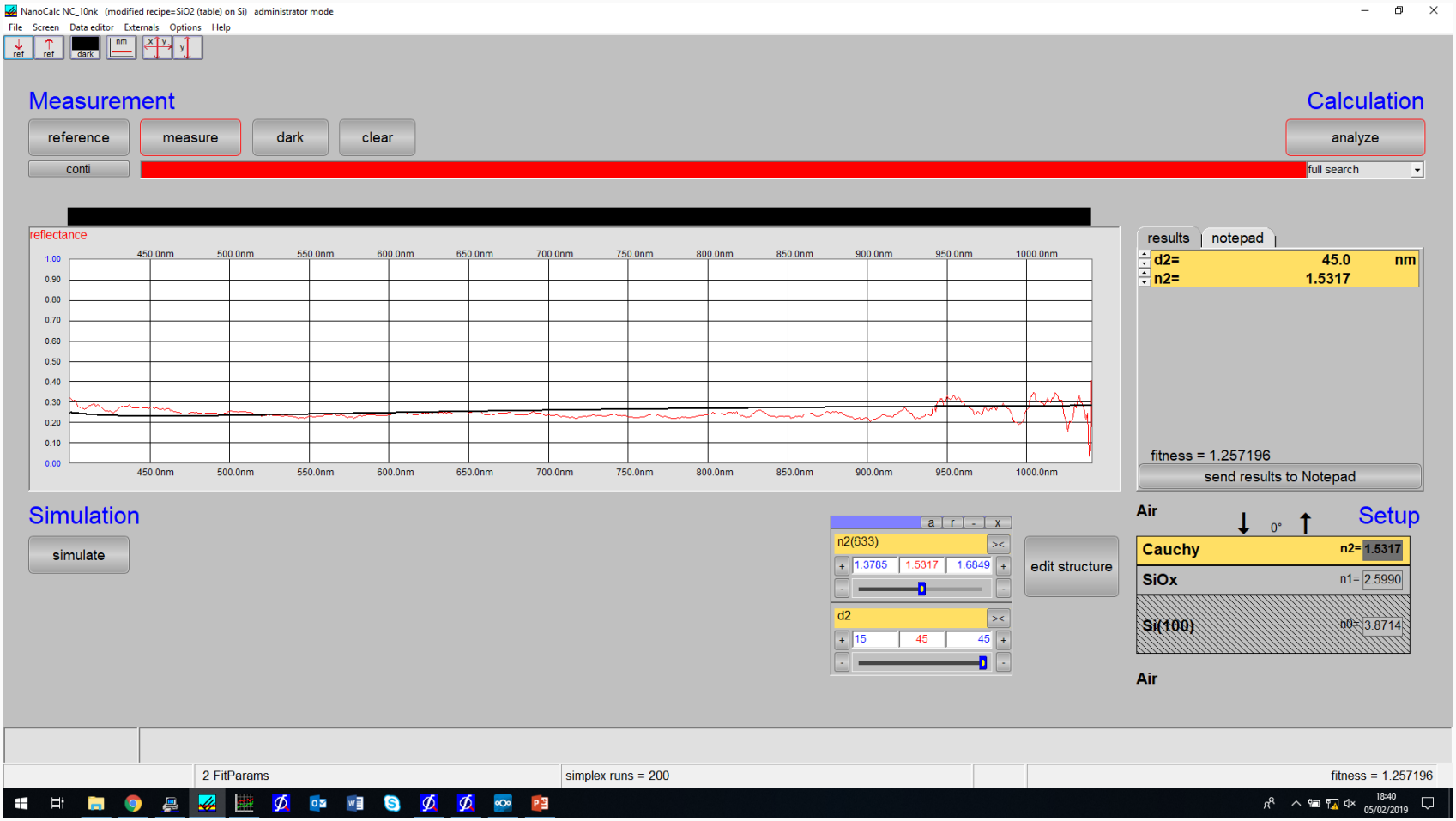
Isoprene Results



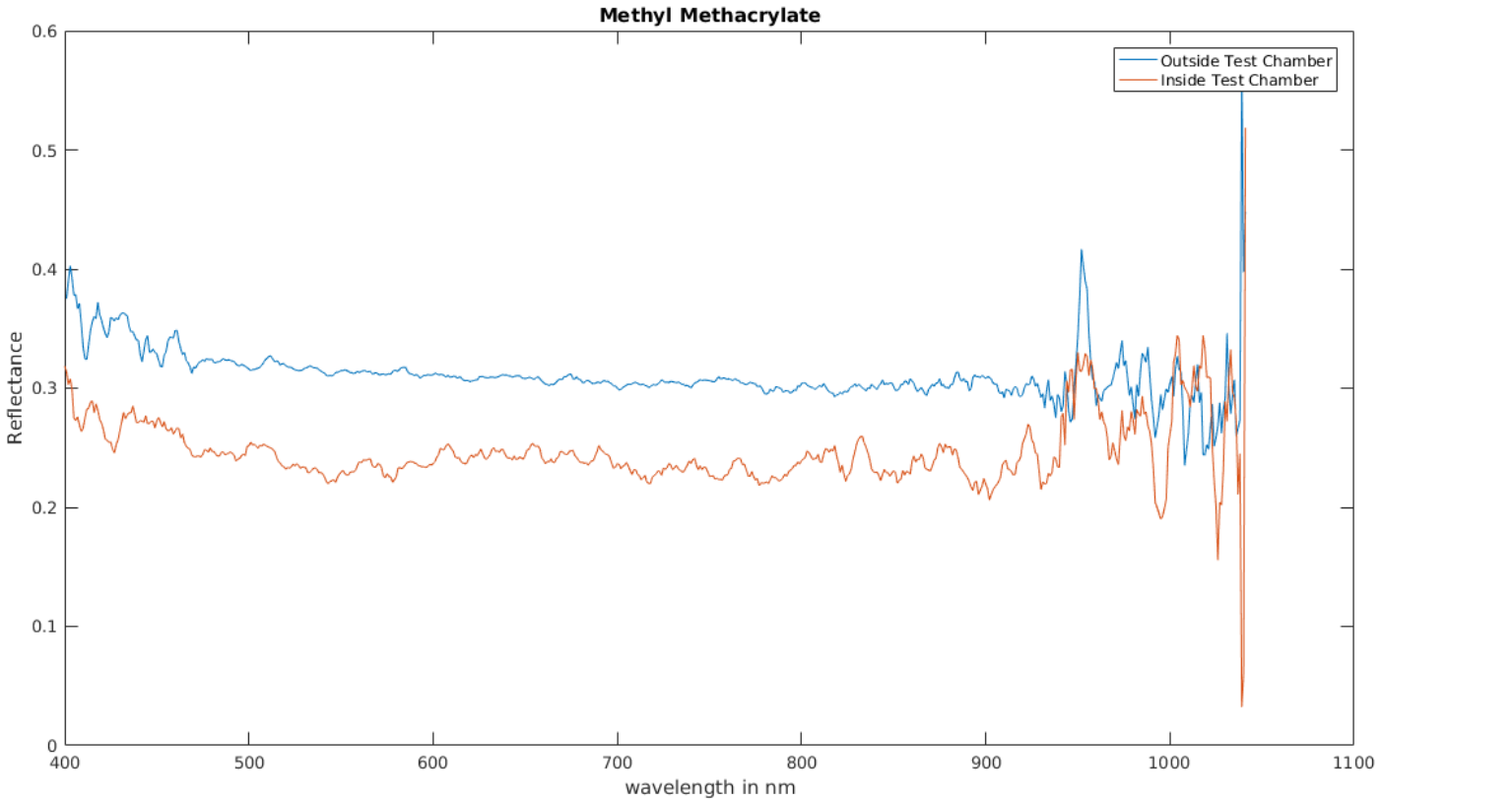
Methyl Methacrylate Results



Methyl Methacrylate Results



Methyl Methacrylate Results



Future plans

- Tools to analyse reflectance curves.
- Model the lens in test chamber setup.
- Refine the experimental protocol.
- Investigate the polymers.
- Begin to investigate diblock polymers.
- Begin to investigate other options for modelling the polymers.

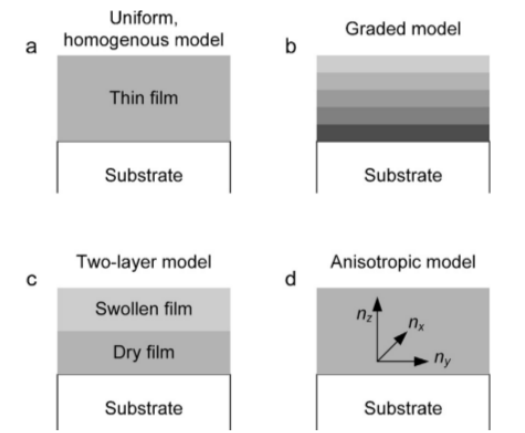


Fig. 8. Optical models used in typical in situ ellipsometry measurements of swollen polymer films.