Optical Simulations of Ion Implanted Layers for Advanced Gravitational-Wave Detection

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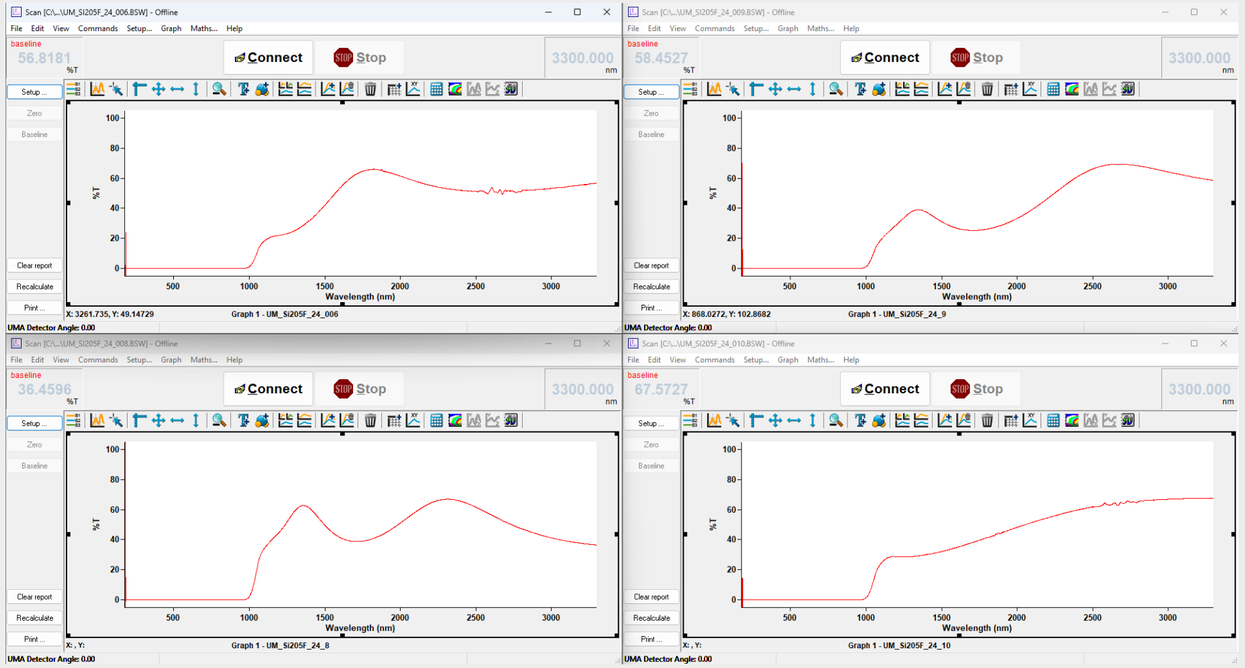
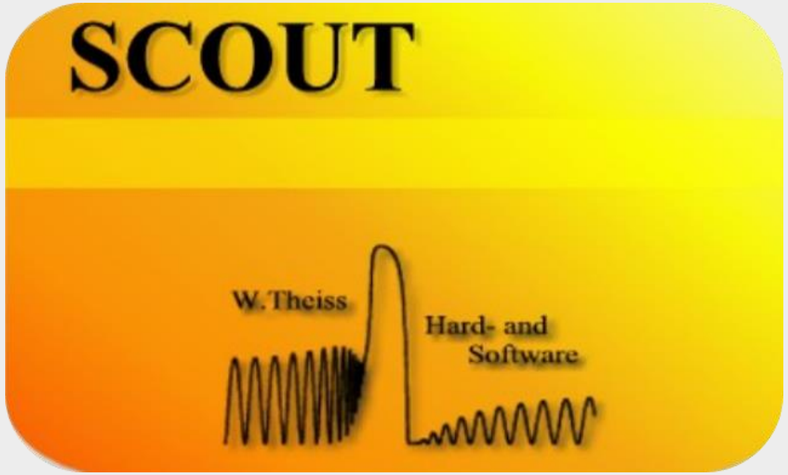
Experimental Measurements

- The transmission spectra were measured using a UV-Vis spectrophotometer within a range of 175 nm to 3300 nm.
- The obtained spectra were later implemented in an analysis software to optically extract the thickness and the refractive index.



Software presentation

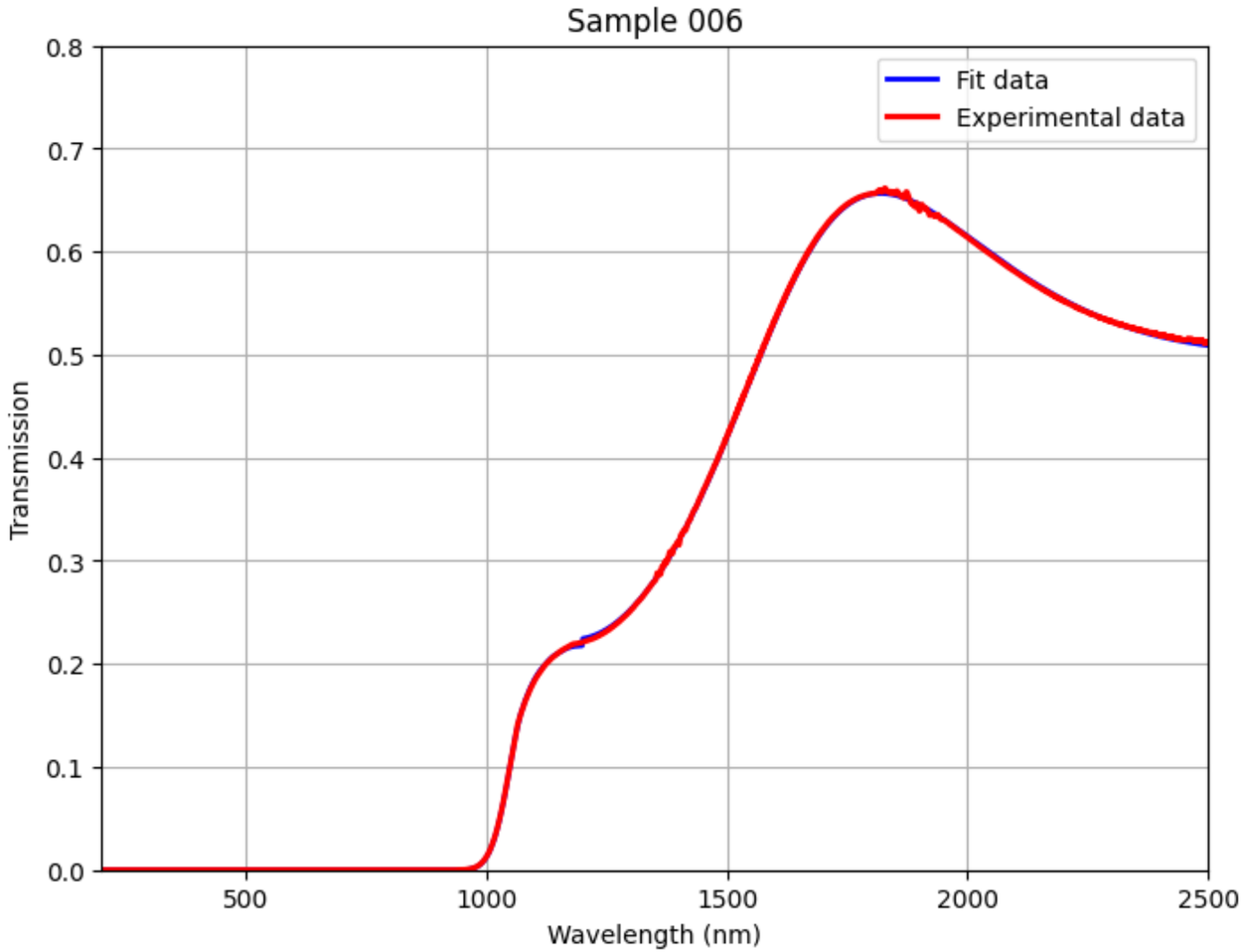
- **"SCOUT"** is a thin film analysis software, it's mostly used to extract parameters from optical measurements, by comparing them to simulated ones, based on physical modelling.
- After successfully fitting the simulated spectra to the experimental one, we are able to get optical parameters such as the refractive index.

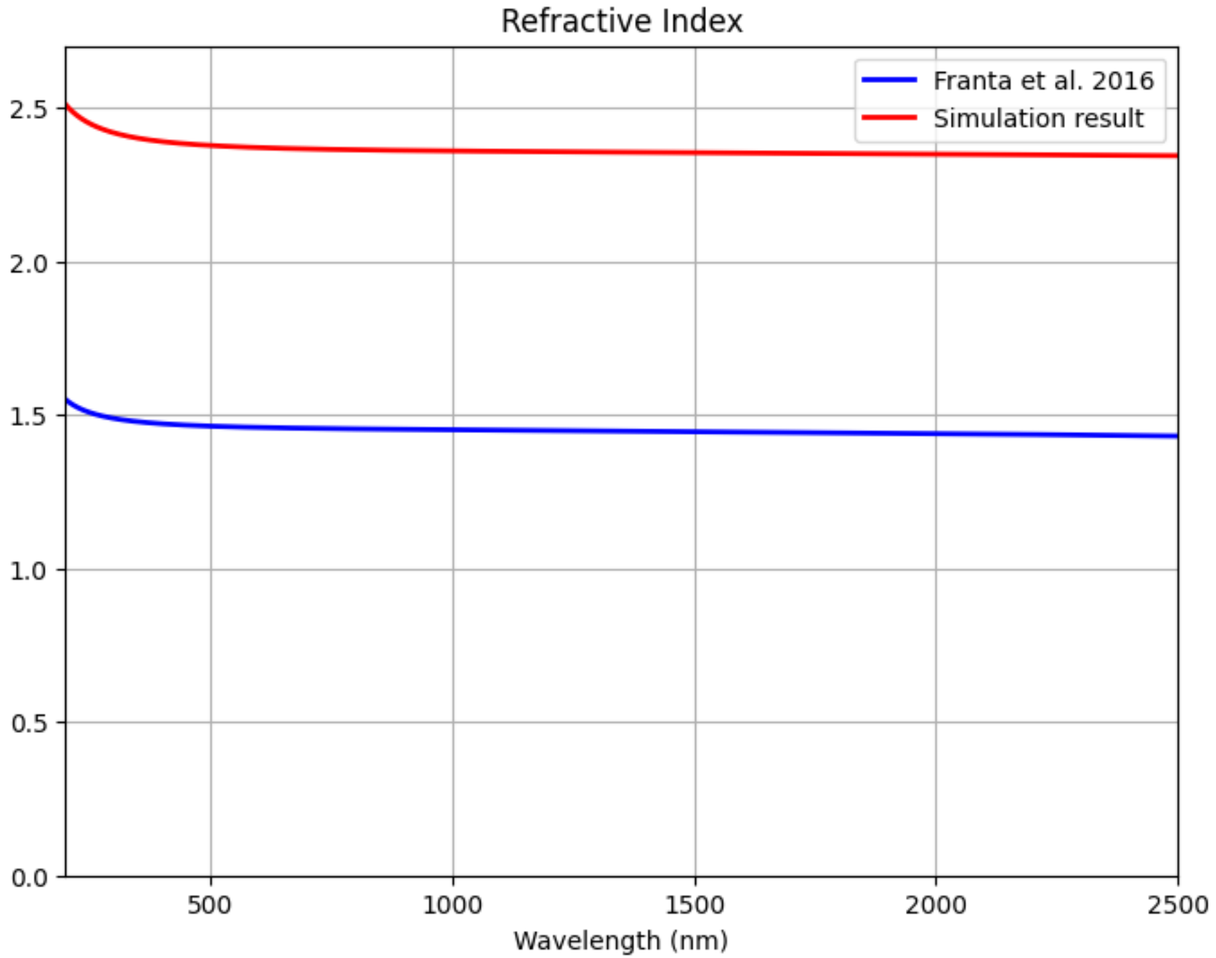


Samples studied & Results

- We studied and fitted 5 samples with different layouts.

- Sample 006:
  - Implanted with 2 layers of oxygen at different depths.
  - The first implanted layer is the shallow layer with a low energy (L), followed by a deeper layer with high energy (H).
  - The refractive indices obtained are:
    - At 1064 nm: $n(L) = 2.35\,;\, n(H) = 2.36$
    - At 1550 nm: $n(L) = 2.35\,;\, n(H) = 2.36$



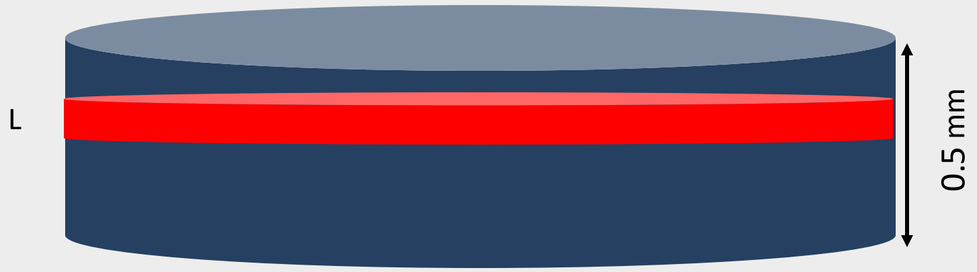


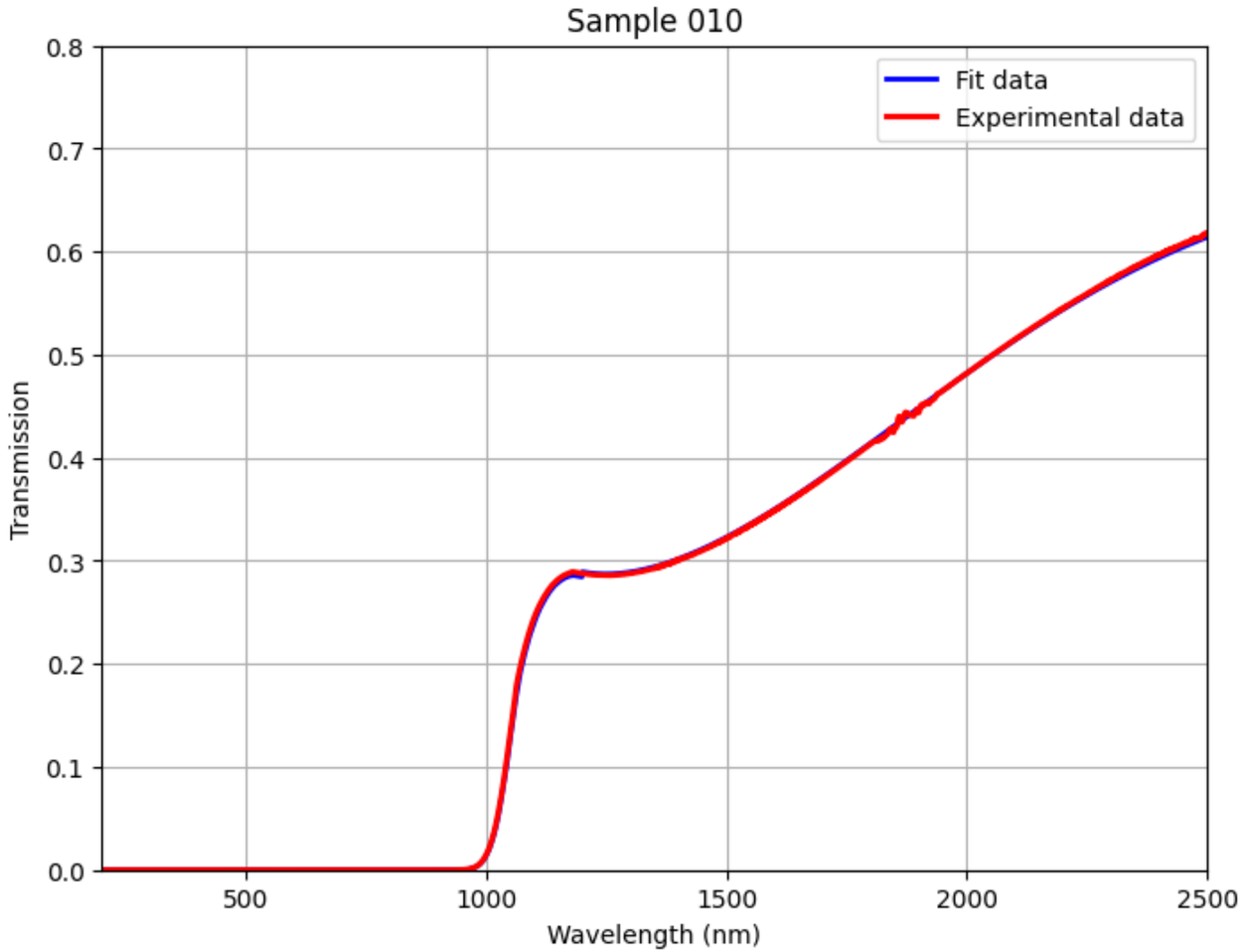
Type of layer	Material & Model	Thickness
Vacuum	Vacuum	
Thin film	Crystaline silicon	75.9 nm
Thin film	SiO_2 Sellmeier model	135 nm
Thin film	Crystaline silicon	61.8 nm
Thin film	SiO_2 Sellmeier model	180 nm
Thick layer	Crystaline silicon	0.5 mm
Vacuum	Vacuum	

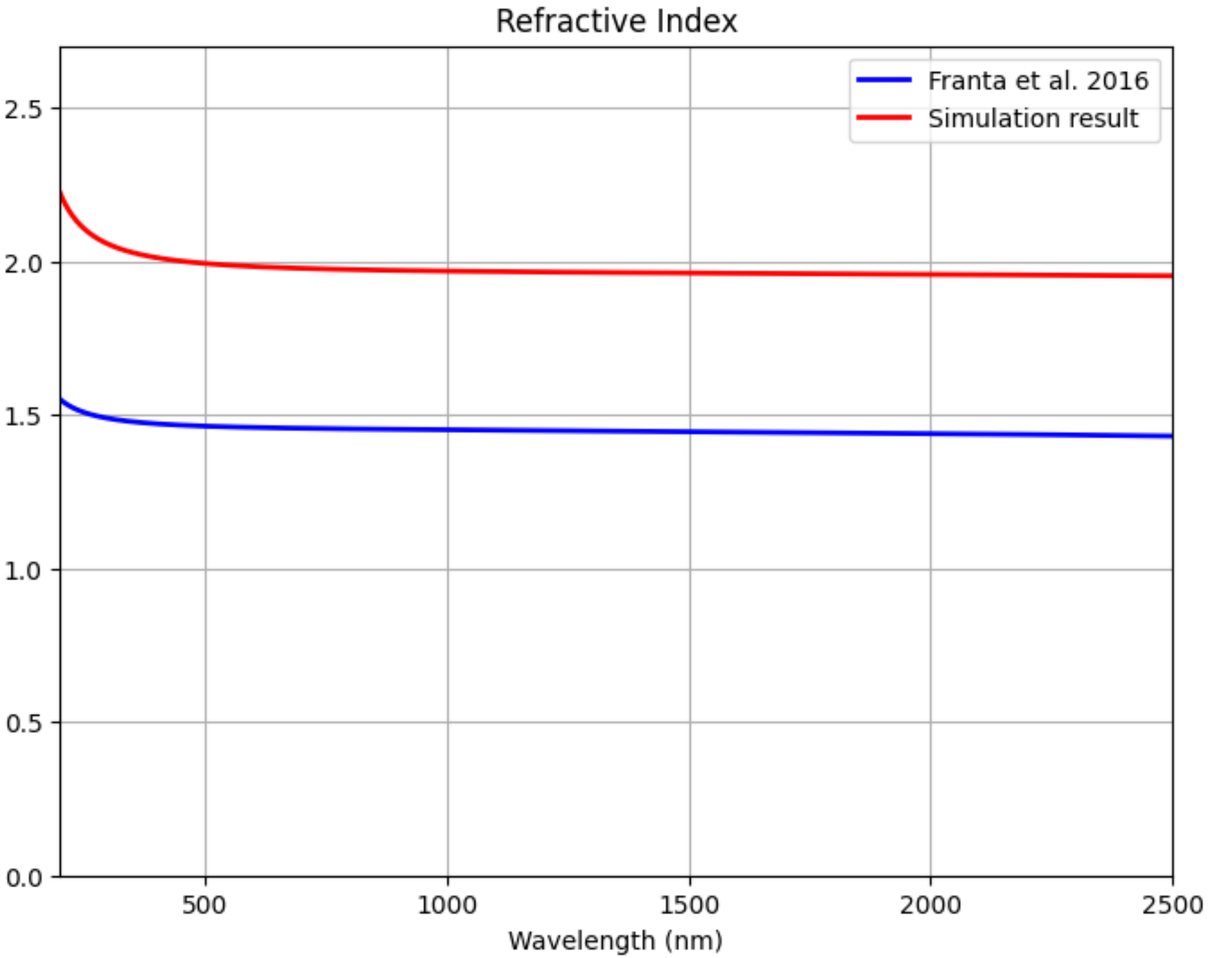
Samples studied & Results

- We studied and fitted 5 samples with different layouts.

- Sample 010:
  - Implanted with 1 layer of oxygen at a shallow depth.
  - The refractive indices obtained are:
    - At 1064 nm: $n = 1.96$
    - At 1550 nm: $n = 1.96$





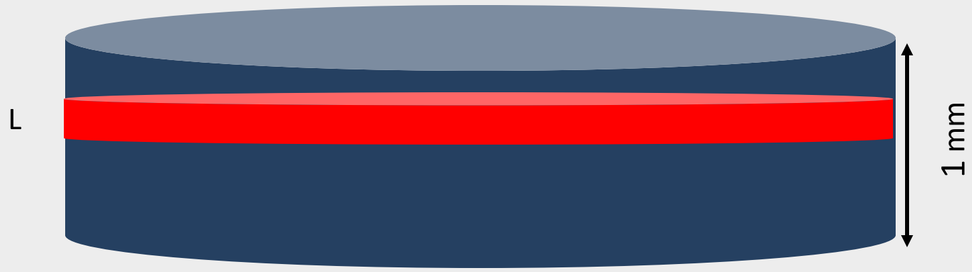


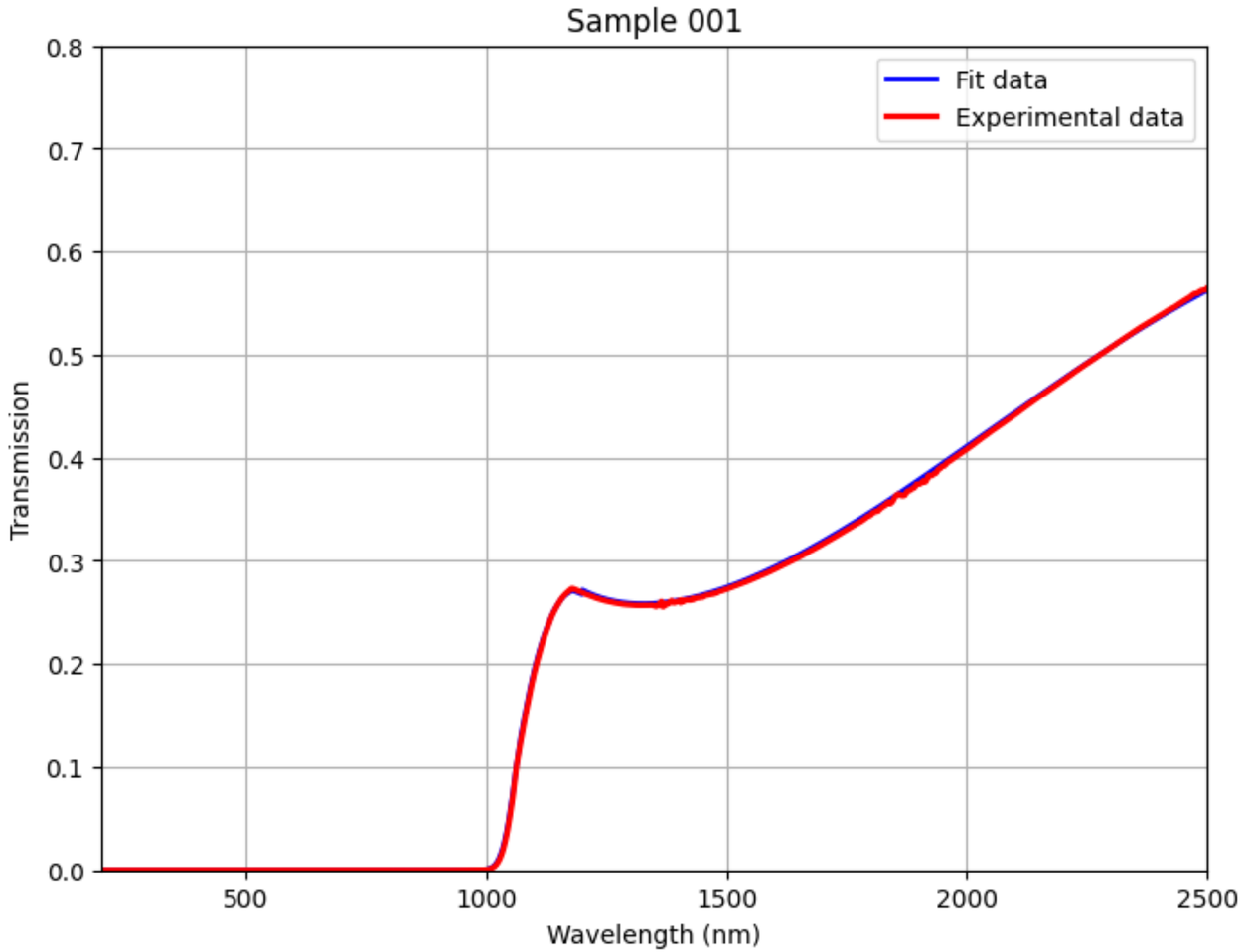
Type of layer	Material & Model	Thickness
Vacuum	Vacuum	
Thin film	Crystaline silicon	72.3 nm
Thin film	SiO_2 Sellmeier model	197 nm
Thick layer	Crystaline silicon	0.5 mm
Vacuum	Vacuum	

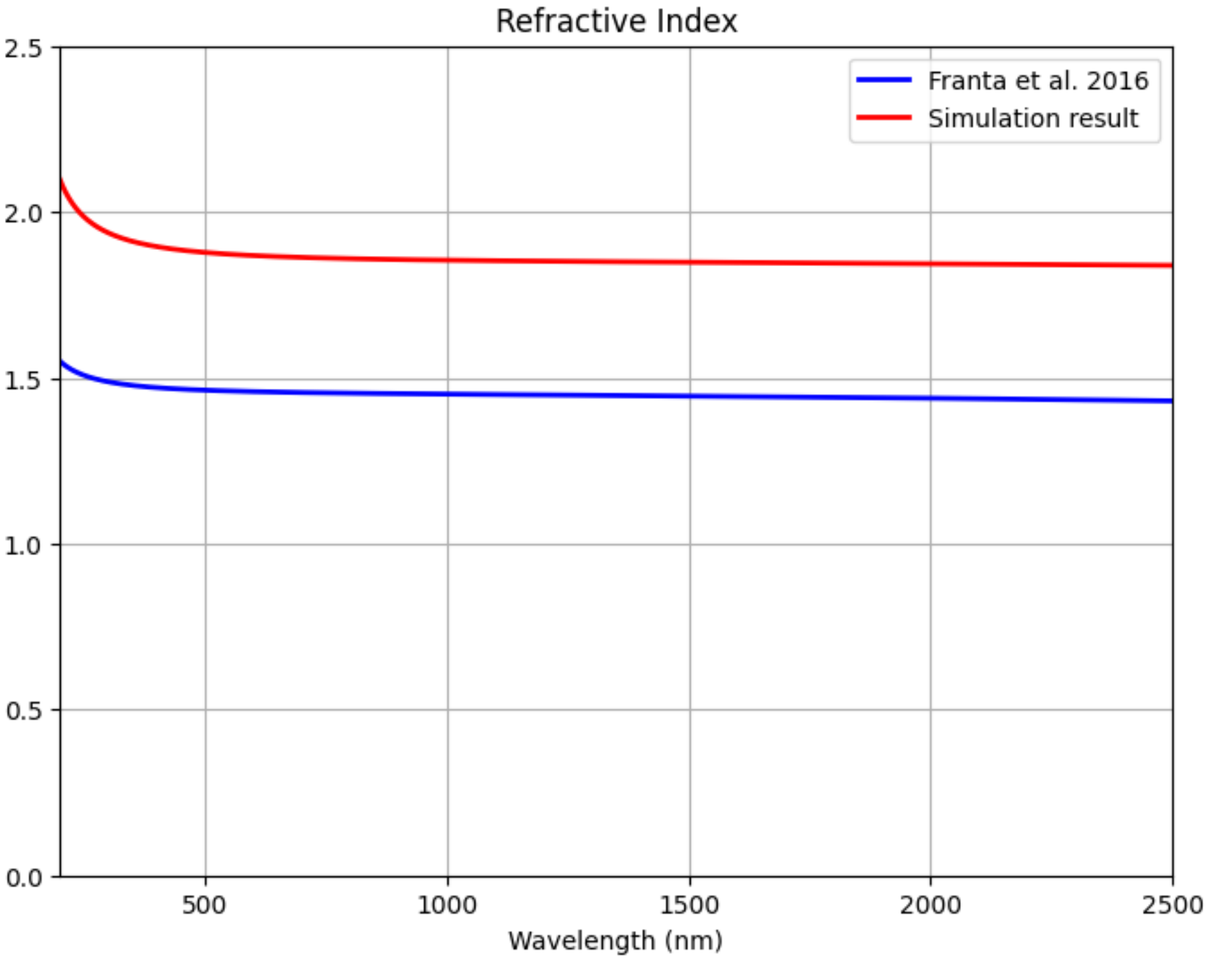
Samples studied & Results

- We studied and fitted 5 samples with different layouts.

- Sample 001:
  - Implanted with 1 layer of oxygen at a shallow depth.
  - Higher dosage of oxygen compared to sample 010, and thicker substrate
  - The refractive indices obtained are:
    - At 1064 nm: $n = 1.85$
    - At 1550 nm: $n = 1.84$





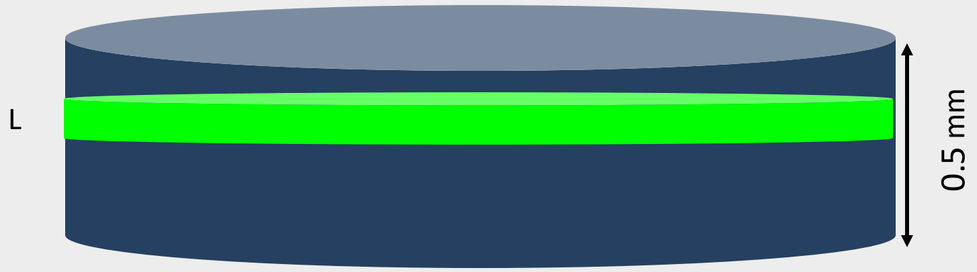


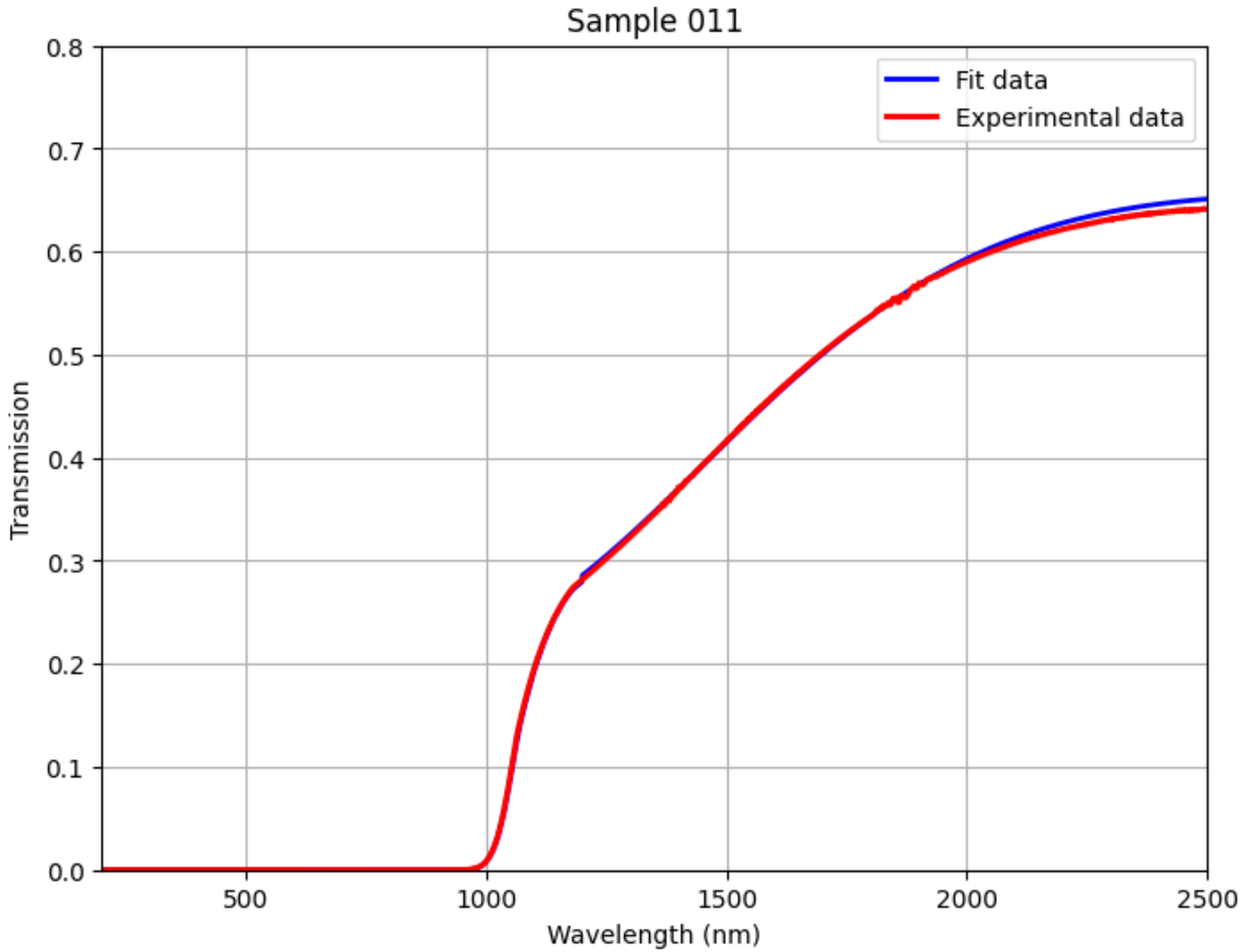
Type of layer	Material & Model	Thickness
Vacuum	Vacuum	
Thin film	Crystaline silicon	83.1 nm
Thin film	SiO_2 Sellmeier model	210.1 nm
Thick layer	Crystaline silicon	1 mm
Vacuum	Vacuum	

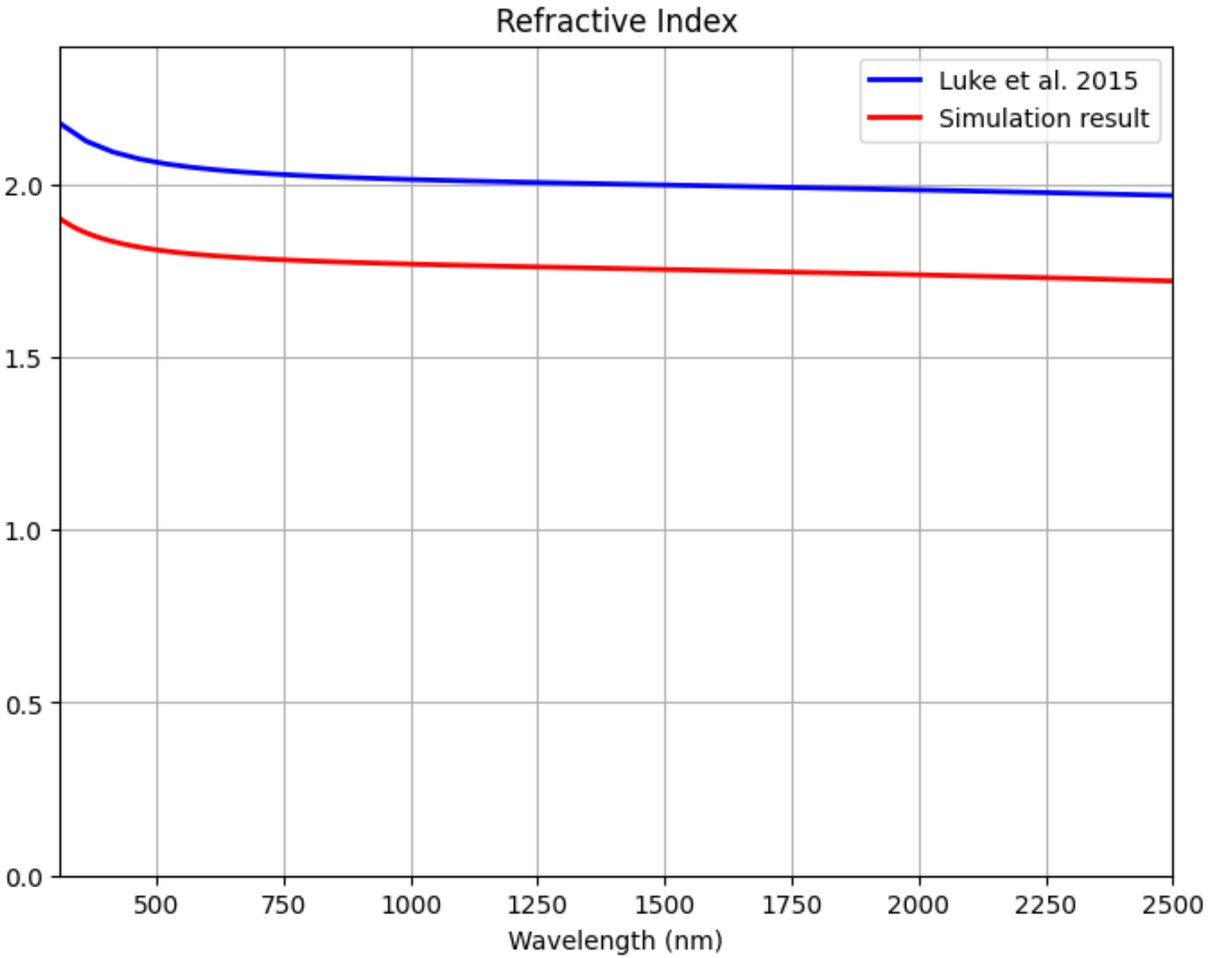
Samples studied & Results

- We studied and fitted 5 samples with different layouts.

- Sample 011:
  - Implanted with 1 layer of nitrogen at a shallow depth.
  - The refractive indices obtained are:
    - At 1064 nm: $n = 1.76$
    - At 1550 nm: $n = 1.75$





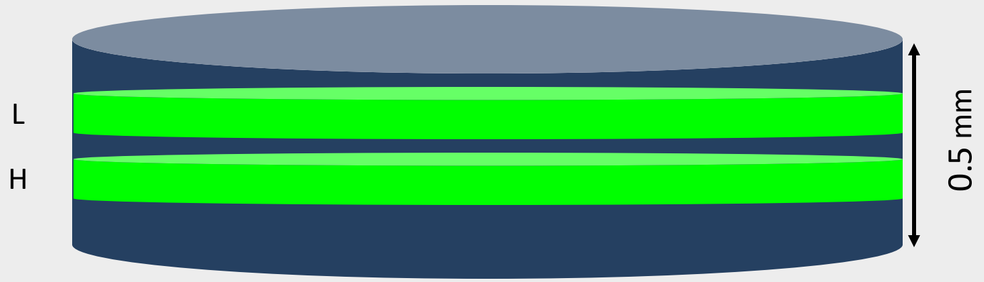


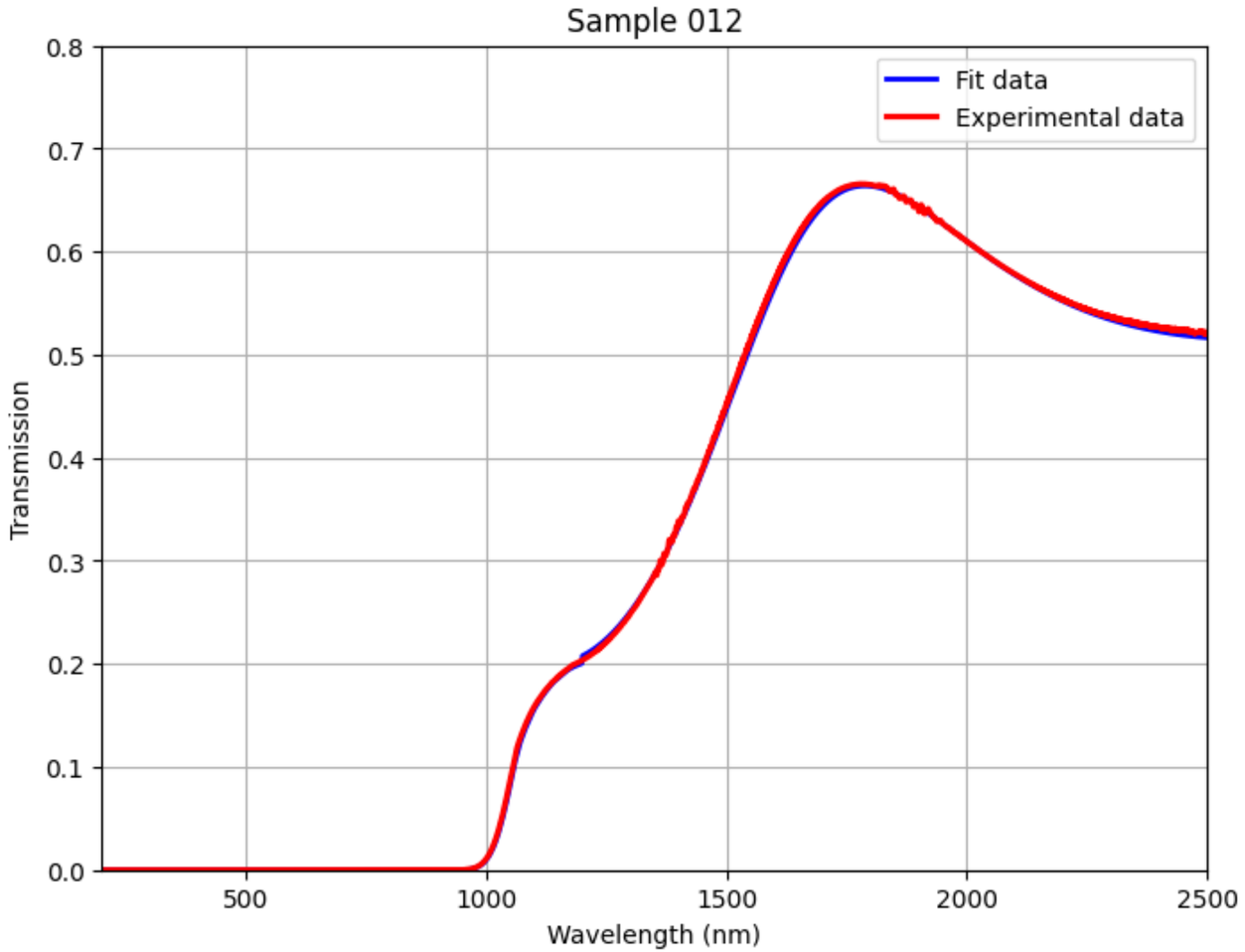
Type of layer	Material & Model	Thickness
Vacuum	Vacuum	
Thin film	Crystaline silicon	79.8 nm
Thin film	SiN Sellmeier model	106.9 nm
Thick layer	Crystaline silicon	0.5 mm
Vacuum	Vacuum	

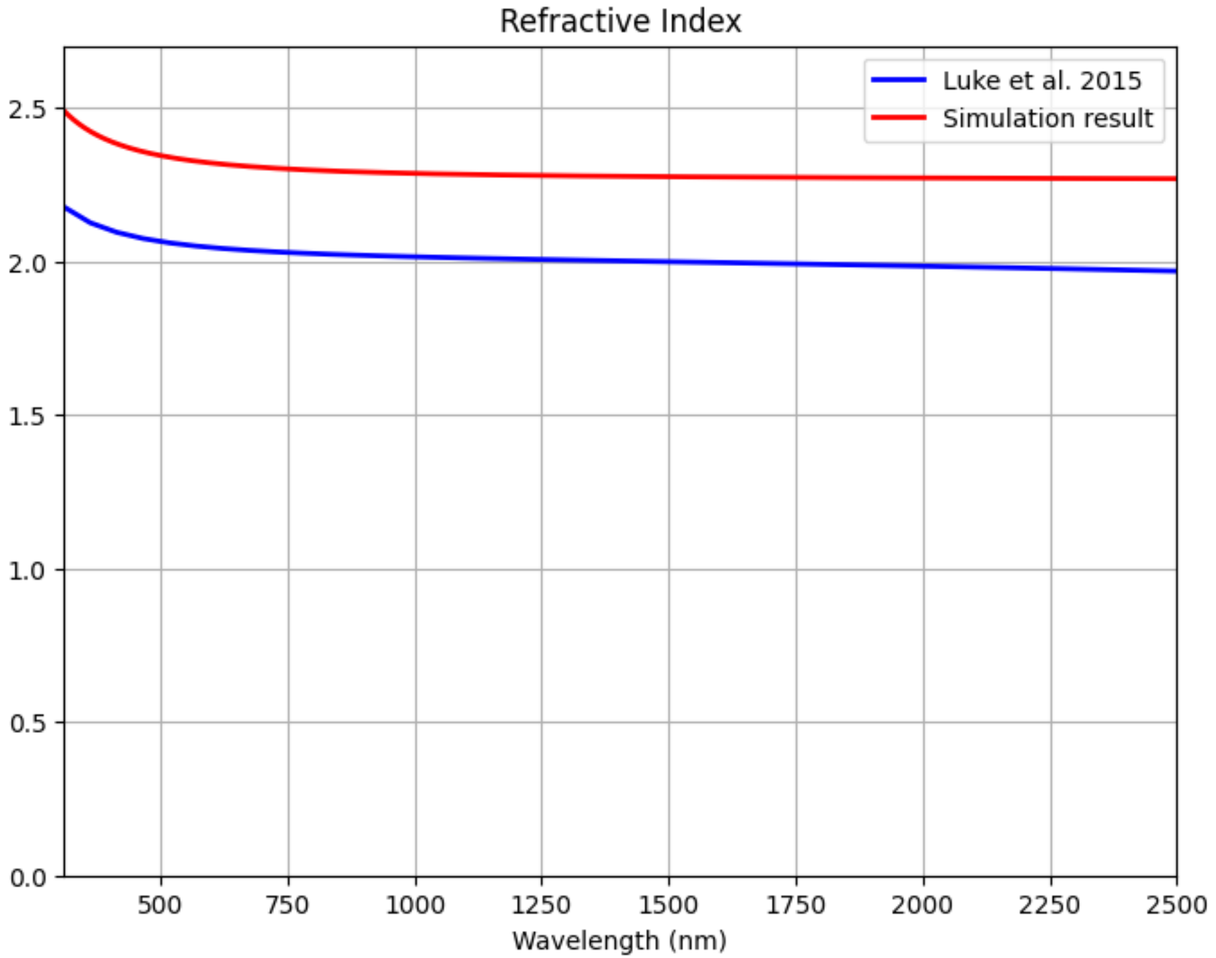
Samples studied & Results

- We studied and fitted 5 samples with different layouts.

- Sample 012:
  - Implanted with 2 layers of nitrogen at different depths.
  - The first implanted layer is the shallow layer with a low energy (L), followed by a deeper layer with high energy (H).
  - The refractive indices obtained are:
    - At 1064 nm: $n(L) = 2.33\,;\, n(H) = 2.33$
    - At 1550 nm: $n(L) = 2.32\,;\, n(H) = 2.32$







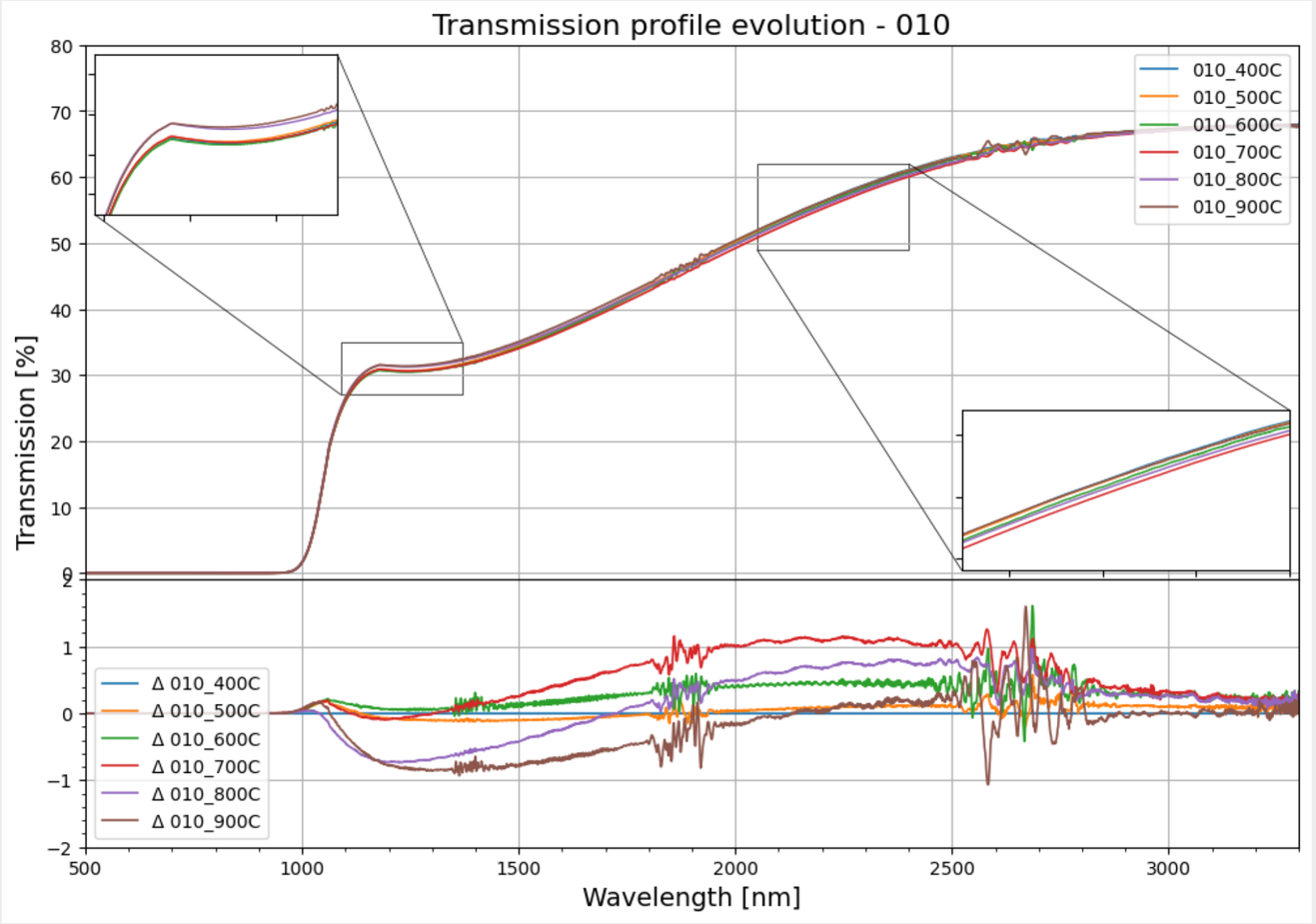
Type of layer	Material & Model	Thickness
Vacuum	Vacuum	
Thin film	Crystaline silicon	71.2 nm
Thin film	SiN Sellmeier model	134.6 nm
Thin film	Crystaline silicon	65.3 nm
Thin film	SiN Sellmeier model	171 nm
Thick layer	Crystaline silicon	0.5 mm
Vacuum	Vacuum	

Summary

Samples	Simulated Shallow Layer Thickness (nm)	Measured Shallow Layer Thickness (nm)	Simulated Deep Layer Thickness (nm)	Measured Deep Layer Thickness (nm)
Sample 001	210.1	--	--	--
Sample 006	135	194	180	350
Sample 010	197	199	--	--
Sample 011	106.9	176	--	--
Sample 012	134.6	172	171	210

Perspectives

- Working on heat treatment to the study the profile evolution of our samples.
- Working on analysing samples with multilayered structure.
- Characterizing the morphology and stoichiometry of the samples.



Questions?

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