OBUDA UNIVERSITY

Doctoral School on Materials Sciences and Technologies

Institute of Technical Physics and Materials Science
Centre for Energy Research

5th Semester Report On

‘ Non-Destructive Optical Mapping Tool From Cheap Parts ’

By : **Berhane Nugusse Zereay**
Supervisor : **Prof. Dr. Miklós Fried**

25 January, 2024

OUTLINE

1. Introduction
    - 1.1. Aim of the Research
    - 1.2. Research Methods
    - 1.3. Characterization methods
2. Results of the Previous Semester
3. Results of the Actual Semester
4. Plans For the Future Work

1. Introduction

Spectroscopic Ellipsometry (SE)

- Non-destructive, non-invasive and non-intrusive optical technique.
- Measures the relative change in polarization state of the measurement beam.
- The two SE measurable values: Amplitude ratio (**ψ)** and phase difference (**Δ)** between the **p**- and **s**-polarizations.

- **ψ** and **Δ** are related to the wavelength of the light beam '**λ**' and the angle of incidence of the beam '**θ**' at the sample surface, respectively.
- Major Steps: Measurement, Data interpretation, Modelling, Fitting, Evaluation and Results.

1.1. Aim of the Research

- Making an optical mapping tool *prototype* from cheap parts like:

  Tablets, monitors and big screen LCD,LED TV

- Programming the data collection and data processing software

- Making measurements on selected samples and determining the precision of the prototype.

1.2. Research Methods

Original Concept of Prototype building using different parts

1. Light-source (LED-panel)

2. Diffuser sheet

3. Film-polarizer

4. Analyzer

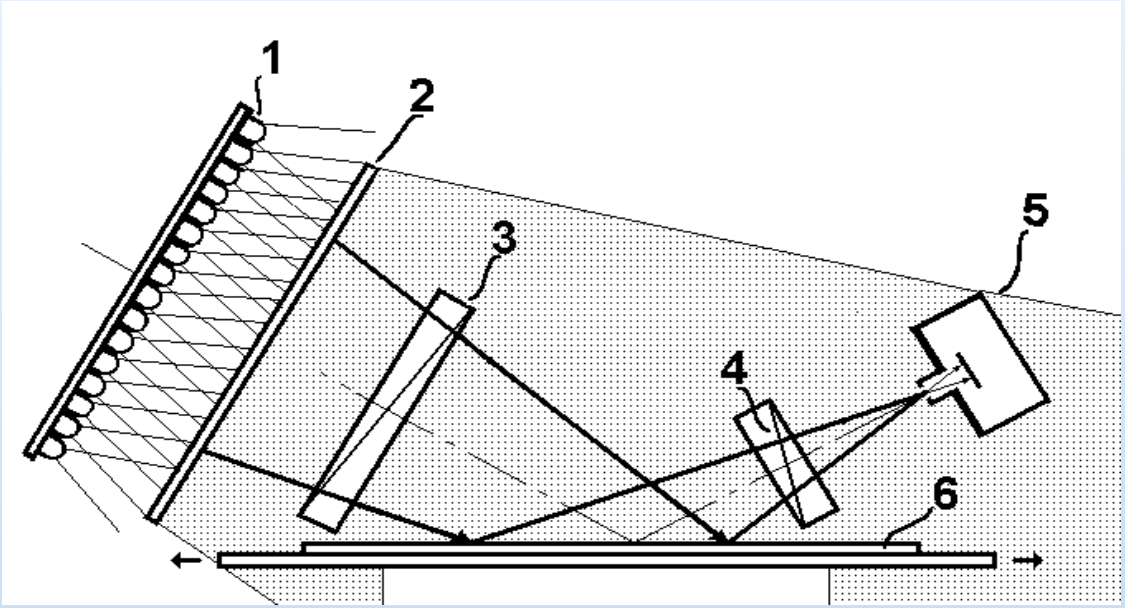


Fig. 1: Original concept of the non-collimated beam ellipsometer

5. Detector (pin-hole + CCD-detector) and

6. Sample

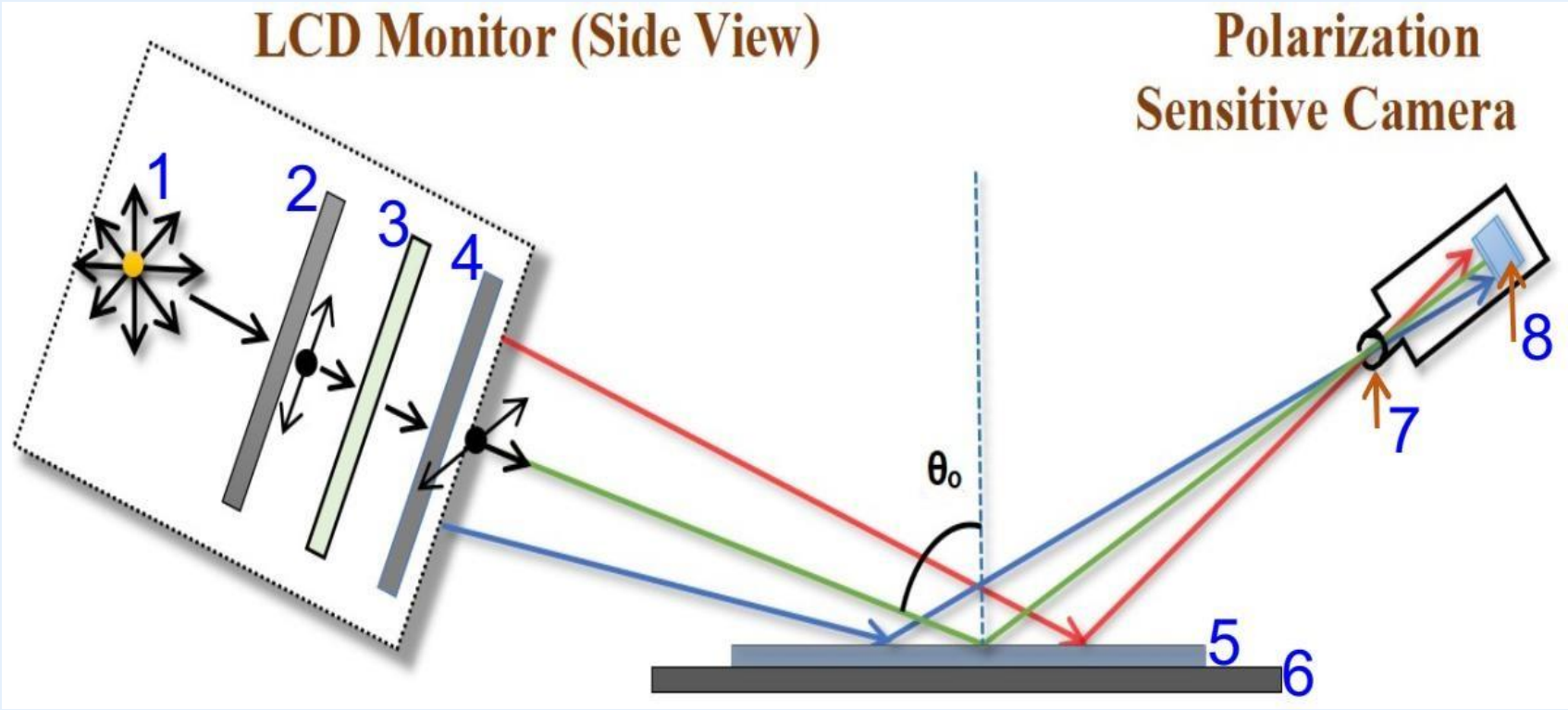


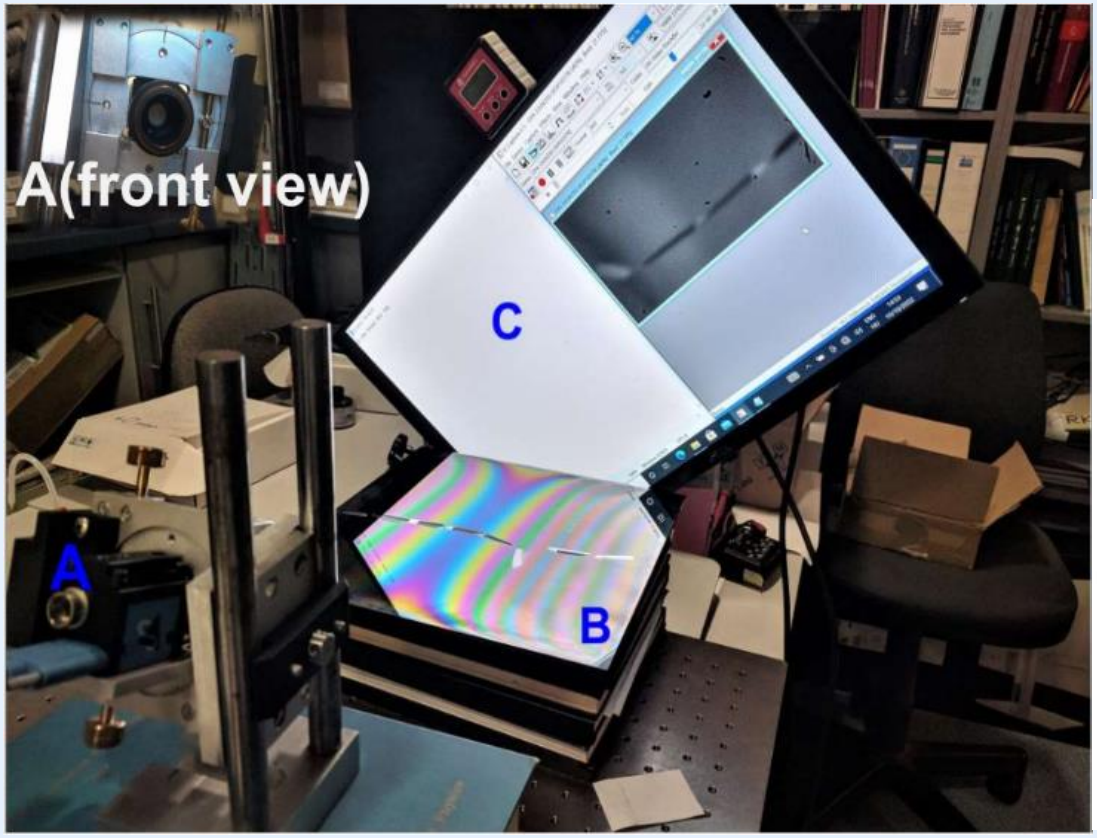
Fig. 2: New concept of the non-collimated beam ellipsometer prototype from cheap parts

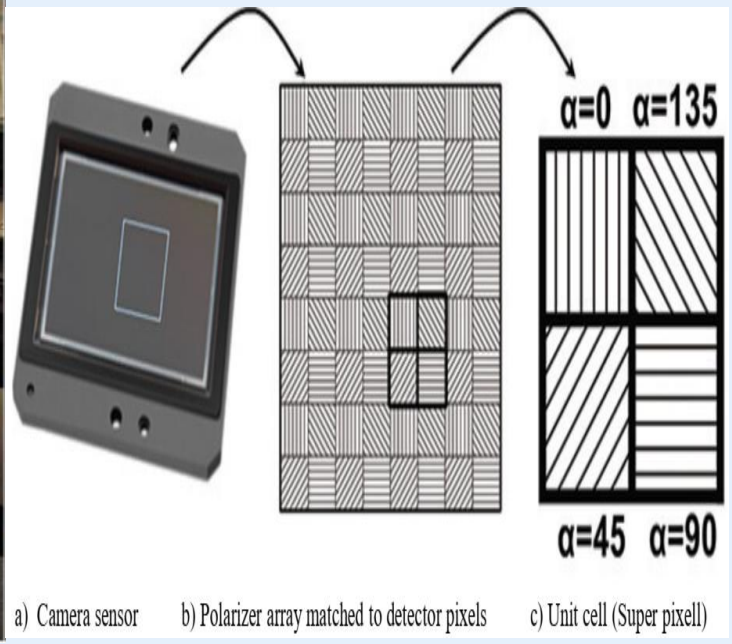
1) Light source **2)** Vertical polarizer **3)** Liquid crystal cell

4) Horizontal polarizer **5)** Sample **6)** Sample holder

7) Pin hole (sub-mm size) and **8)** Camera sensor

The new concept is without the rotating polarizers





a) **b)**

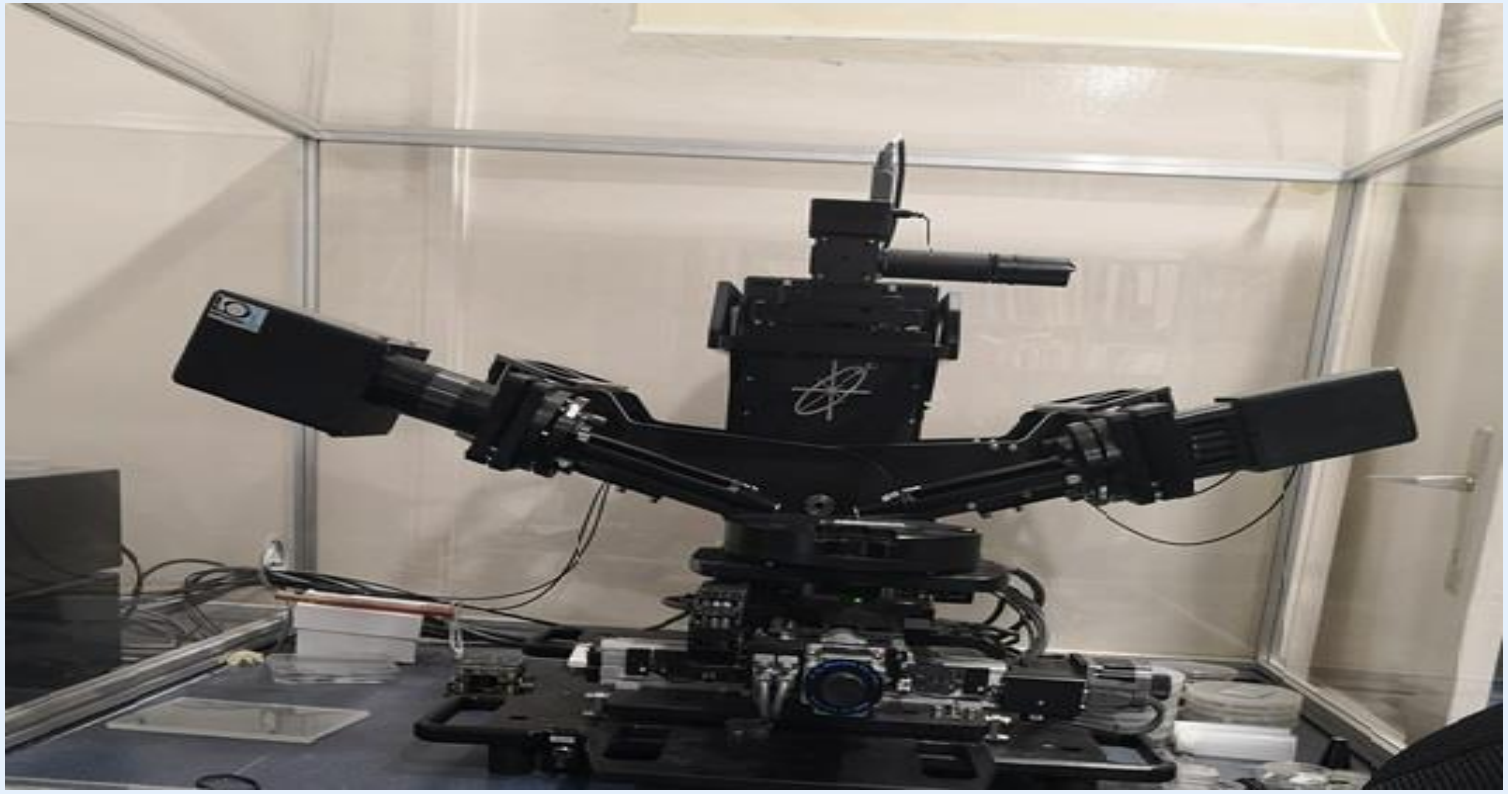
Fig. 3: a) Experimental set up

A) Polarization sensitive camera **B)** Sample + holder **C)** LCD monitor

b) Schematic structure (CMOS Pregius Polarsens sensor),

NB. CMOS sensor is Integrated 4-Directional Wire Grid Polarizer

1.3. Characterization methods



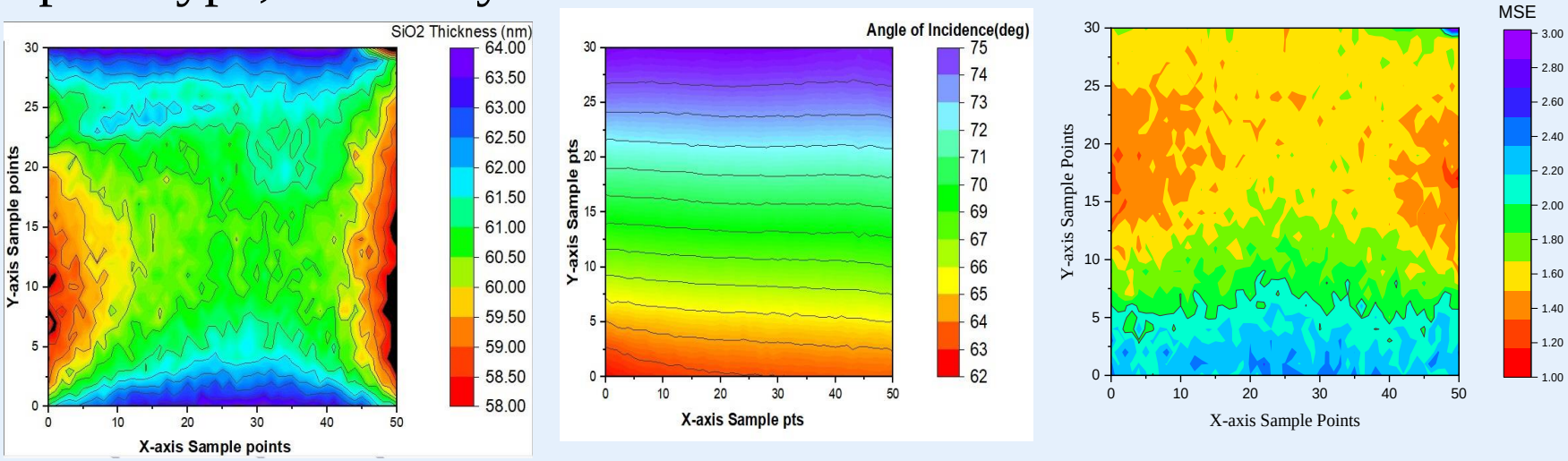
- **Fig. 4**: Rotating Compensator Spectroscopic Ellipsometer (M2000DI)
- The M2000DI ellipsometer is used for control measurements.

Rotating Compensator Spectroscopic Ellipsometer

- Provides fast and very accurate thin film characterization over a wide spectroscopic range.
- Measures film thickness and optical constants on single or multilayer stack.
- Extreme sensitivity for very thin over layers even below 1 nm thickness.
- But it is indirect analysis technique.
- Similar measurements will help the calibration of the prototype.

2. Results of the Previous Semester

- 60nm, **SiO_2/Si** sample *angle of incidence(***AOI***)* calibration, thickness measurement, MSE analysis was done.
- Only, less than 2 nm thickness difference between the M2000 and our prototype, with very low MSE.



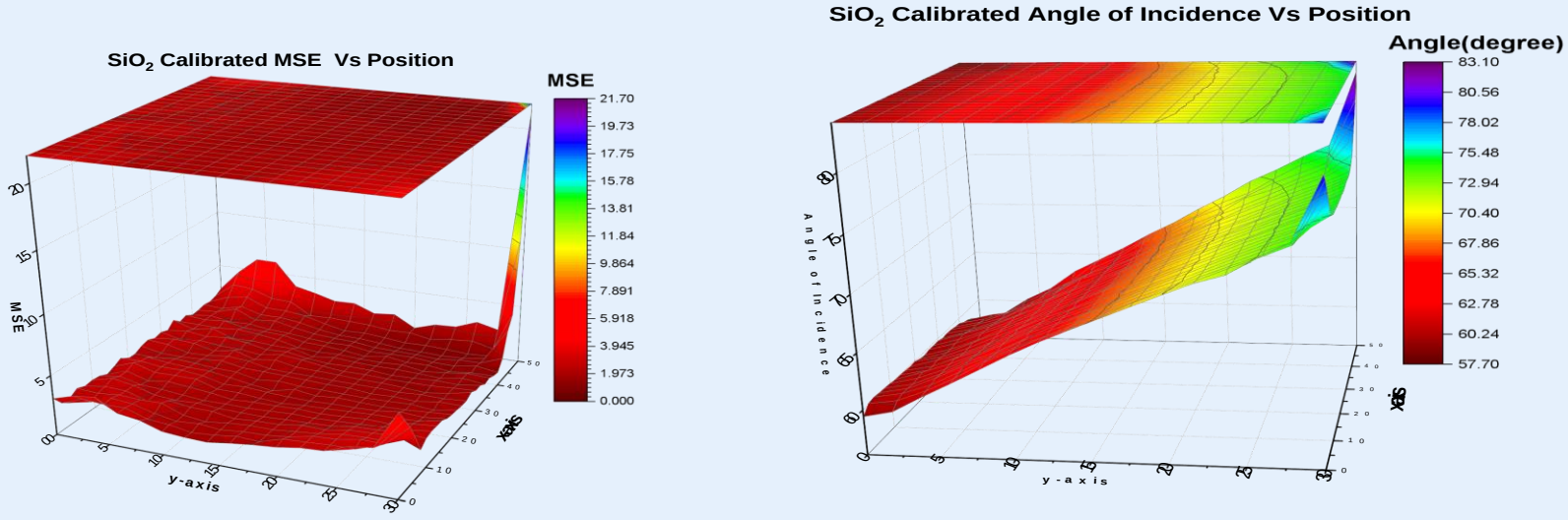
a) **b)** **c)**

Fig. 5: **a)** Thickness vs position

b) Angle of incidence versus position

c) MSE vs position

2. Results of the Previous Semester

- A SiO_2/Si samples on three different positions, hence a better calibration was done.
- A *Poly-Si-on-SiO_2 samples, a* WO_3-MoO_3 combinatorial mixed layers on a 30x30 cm glass sheet,
- A chessboard-like etched silicon dioxide-covered silicon wafer and other experiments were done and reported.
- 

- **Fig 6**. 3D ,MSE and angle of incidence calibration vs position.

3. Results of the Actual Semester

Actual Semester Aim :

- Calibration of the Prototype.

- A measurement on SiO_2 on Si substrate was done on three different sample thicknesses, 60nm, 80nm and 100nm each at more than three different positions, automated with Matlab code software

- Below are some Matlab automated measurement images for a SiO_2/Si samples of 60nm,80nm and 100nm as a startup respectively.

3. Results of the Actual Semester

3.1 60nm SiO_2

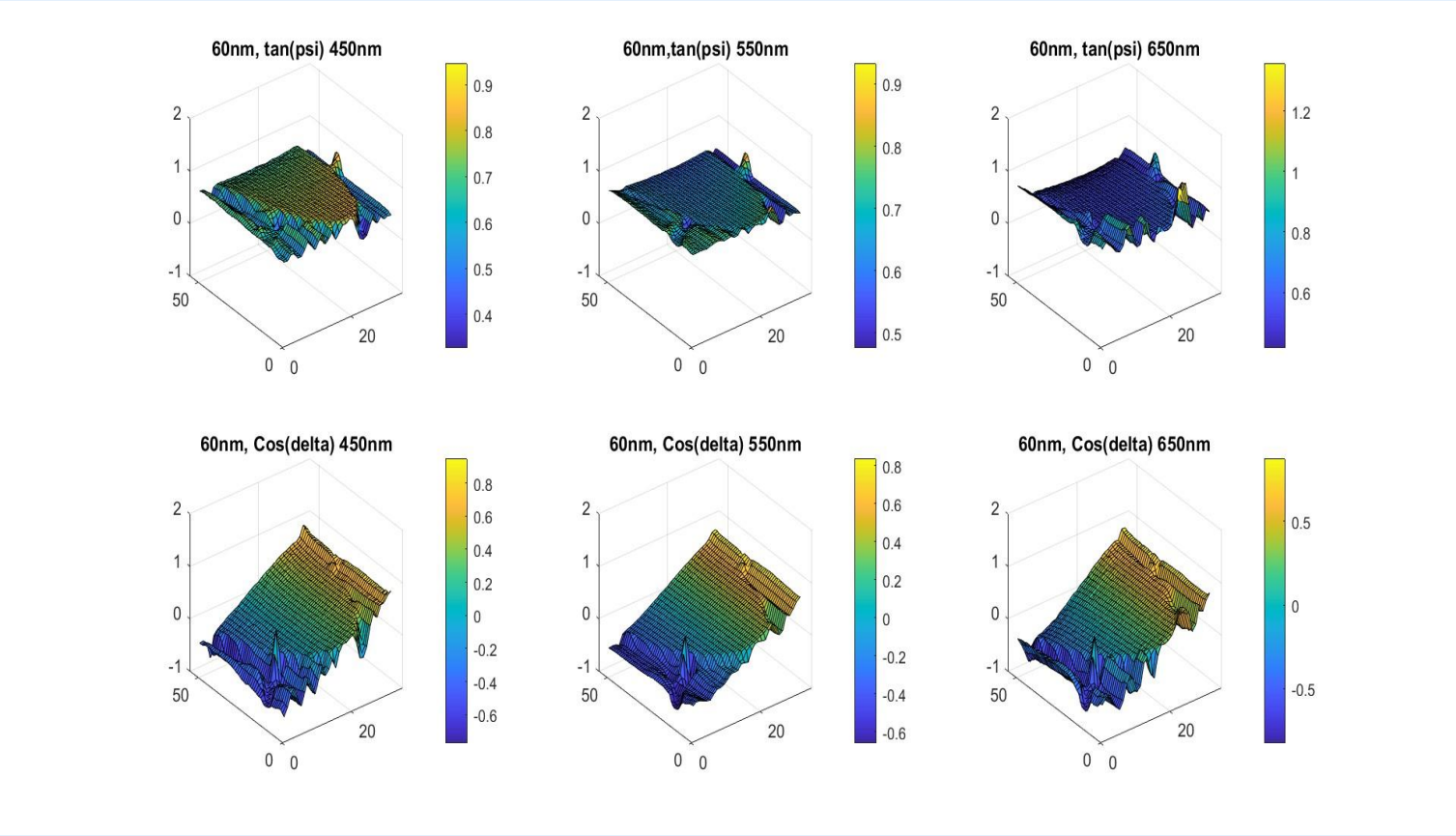


Fig. 7: A 60nm SiO_2/Si sample tan(Ψ) and cos(Δ) measurements for RGB spectrum

3. Results of the Actual Semester

3.1 80nm SiO_2

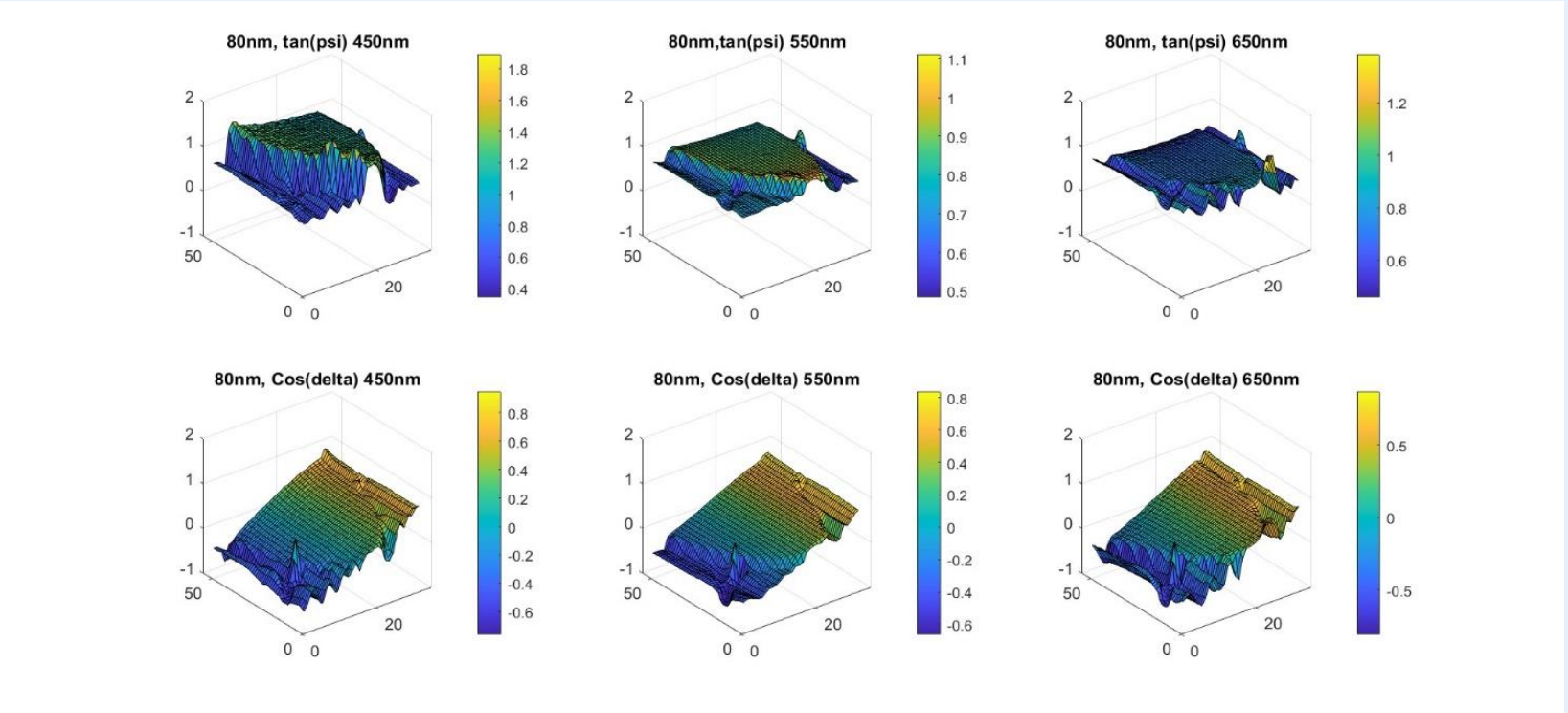


Fig. 8: A 80nm SiO_2/Si sample tan(Ψ) and cos(Δ) measurements for RGB spectrum.

3. Results of the Actual Semester

3.1 100 nm SiO_2 calibration

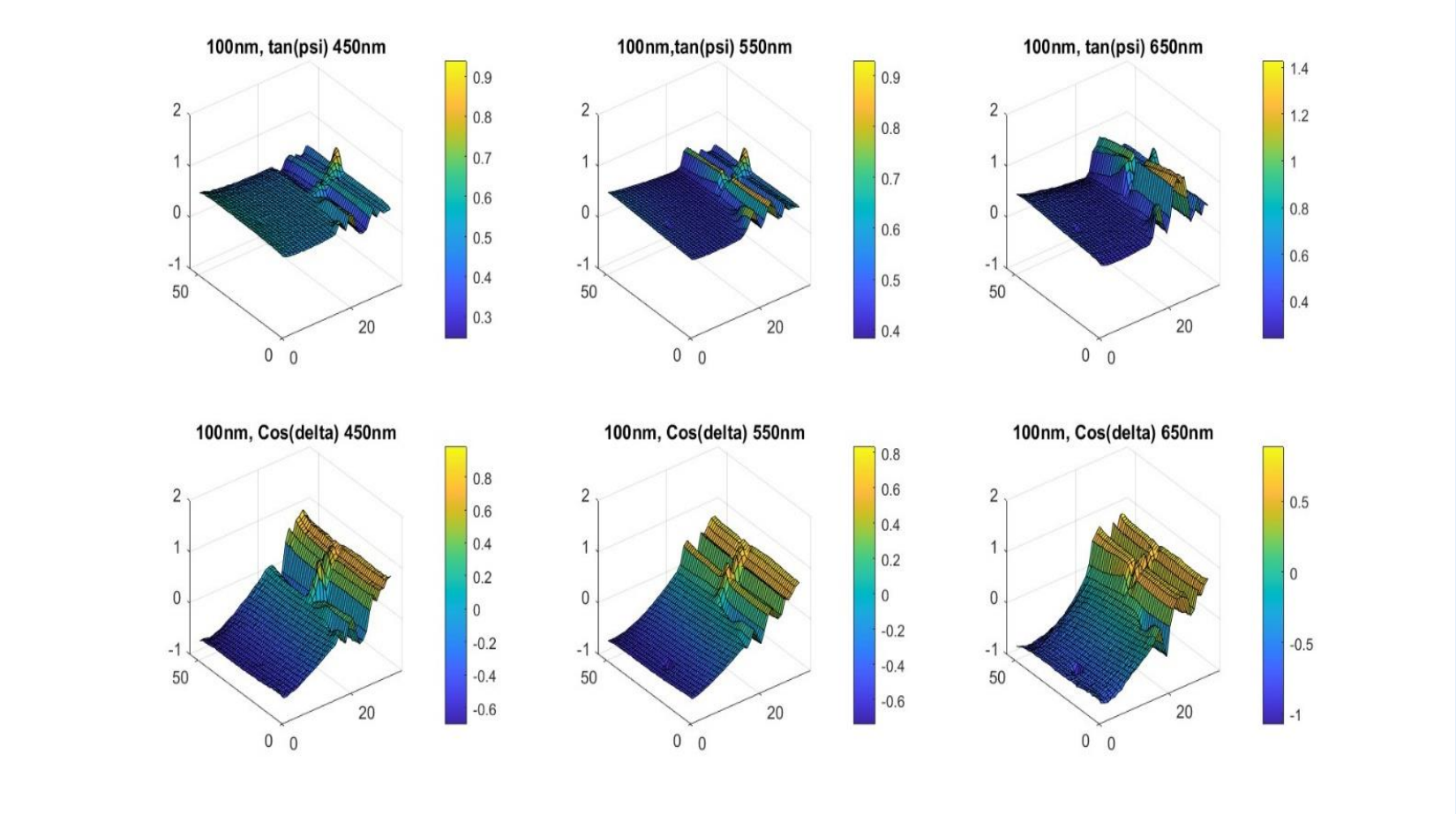


Fig. 9: A 100nm SiO_2/Si sample tan(Ψ) and cos(Δ) measurements for RGB spectrum

General View of the Prototype tool

Advantages

- The new prototype is fast imaging and made up of cheap parts
- Wide mapping area up to 150cm is possible .

Limitations

- Only three wide wavelength bands (RGB) are in action ,which narrows the range of the light band source.
- ‘0.1 degree’ angle uncertainty from the digital angle gauge used in rotation angle of the LCD, which affects incident polarization state of the light.

Current Semester Activities

- 12th Workshop on Spectroscopic Ellipsometry (WSE) , September 19-21, 2023 in Prague, in the Czech Republic.
- Budapest School **on Modern** X**-**ray **Science 2023** (October 3-6 , 2023)
- Surface Science Discussions 2024 – Programme , January 9-10, 2024, Online
- and many other online seminars.

4. Plans For the Future Work

- Full calibration of the prototype with automated data analysis and get the apparatus ready for new different samples, Silicon derived thin films and different samples as required.

köszönöm !