OBUDA UNIVERSITY

Doctoral School on Materials Sciences and Technologies

Institute of Technical Physics and Materials Science
Centre for Energy Research

6th Semester Report On

‘ Non-Destructive Optical Mapping Tool From Cheap Parts ’

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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

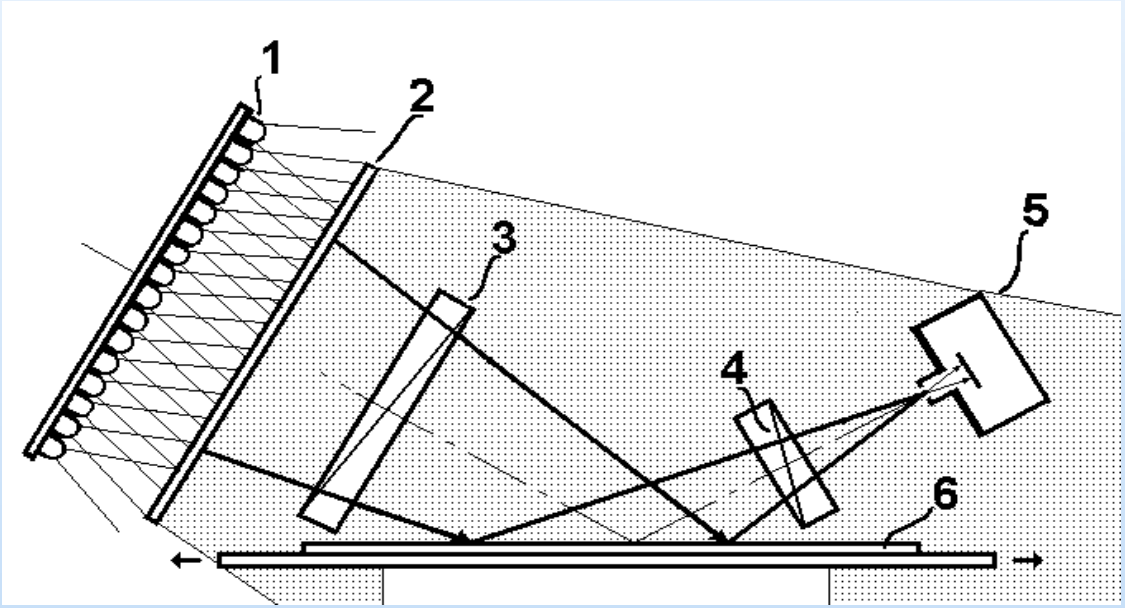


Fig. 1: Original concept of the non-collimated beam ellipsometer

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

6. Sample

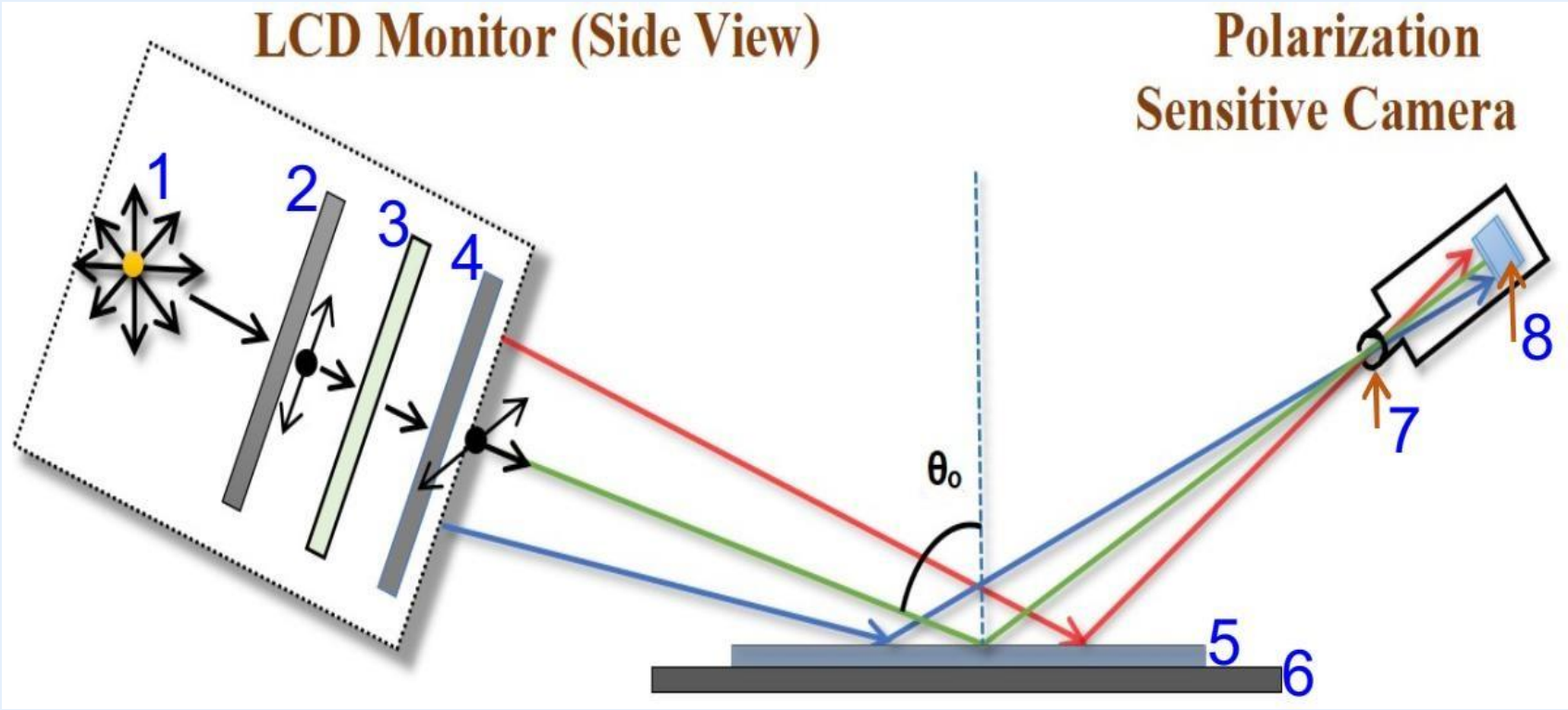


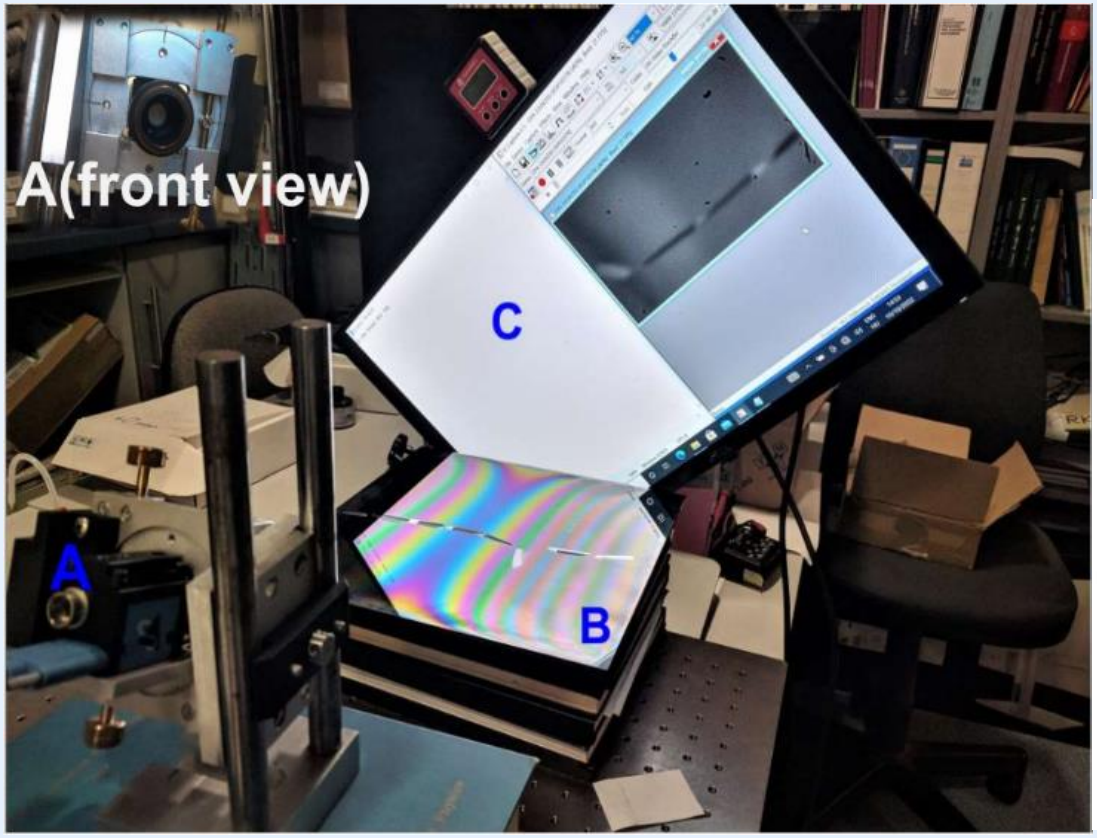
Fig. 2: New concept of the non-collimated beam ellipsometer prototype from cheap parts

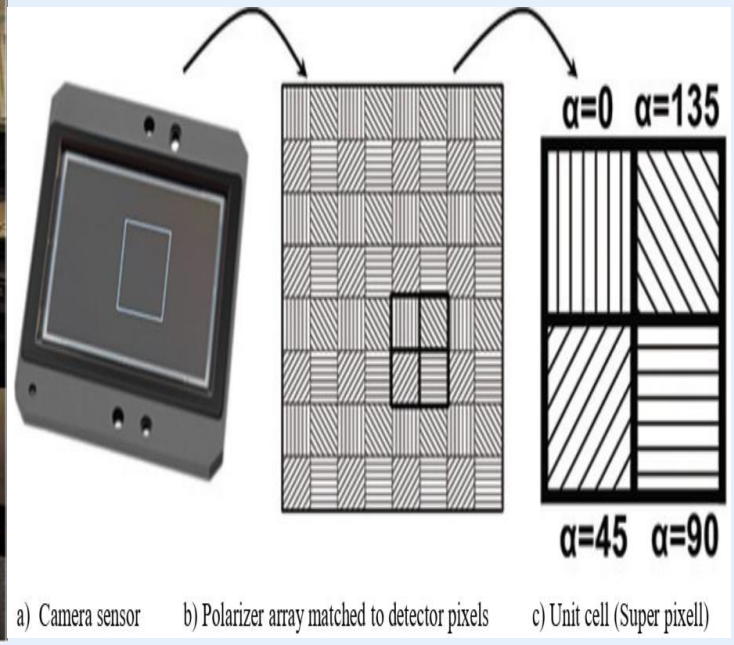
1) Light source **2)** Vertical polarizer **3)** Liquid crystal cell

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)**

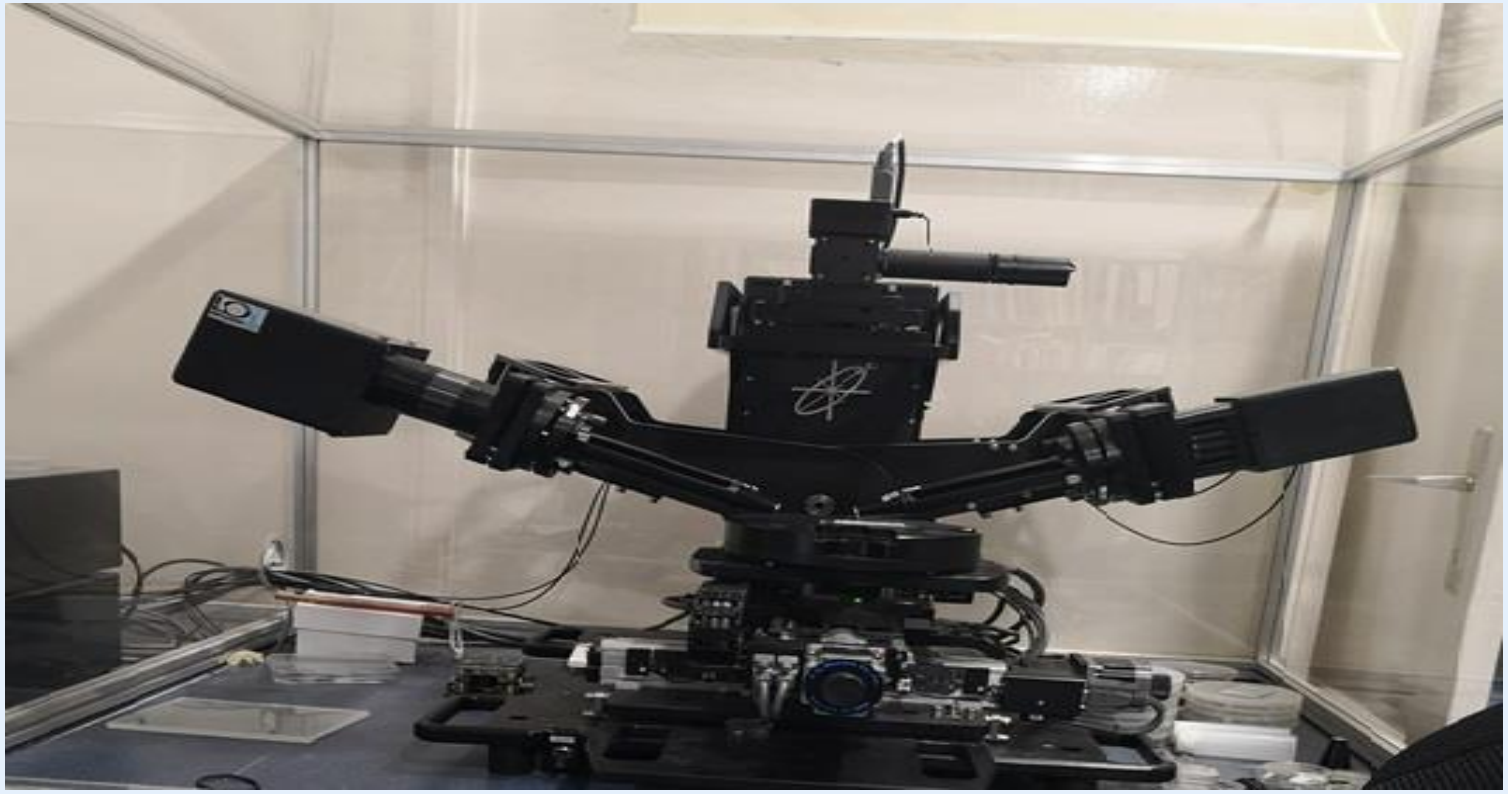
Fig. 3: a) Experimental set up

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



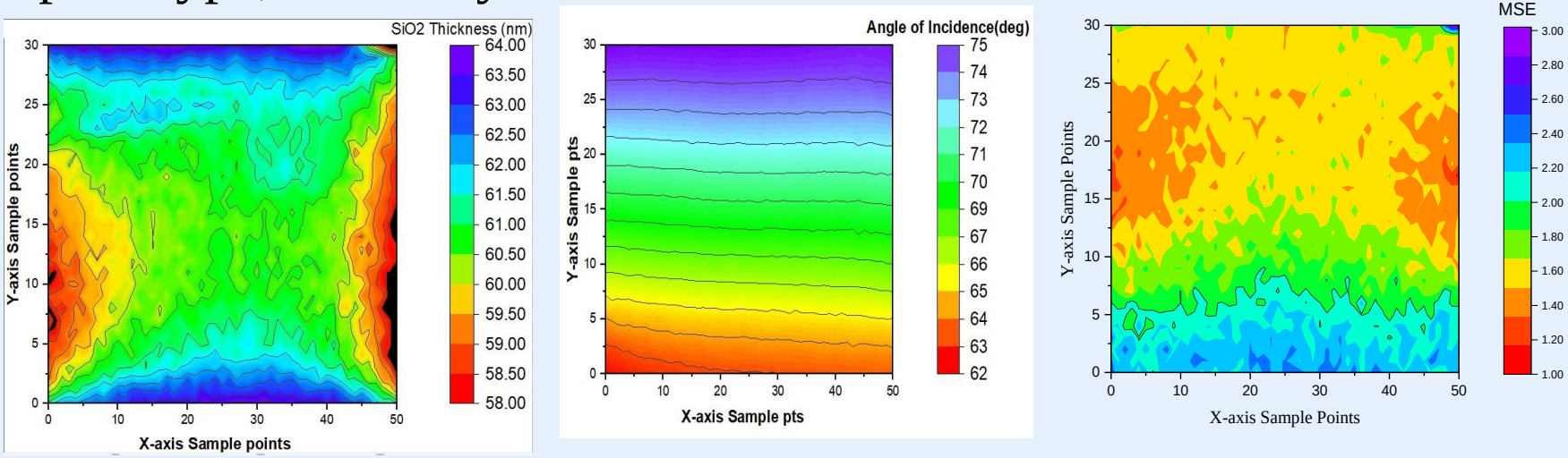
- **Fig. 4**: Rotating Compensator Spectroscopic Ellipsometer (M2000DI)
- The M2000DI ellipsometer is used for control measurements.

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.



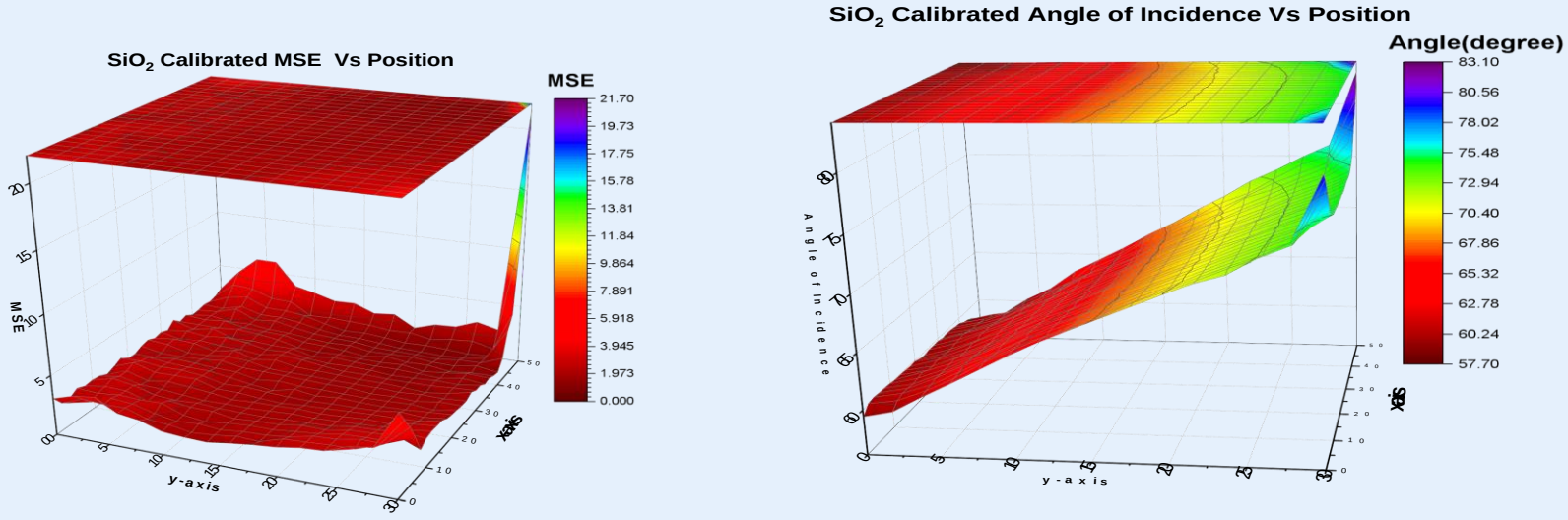
a) **b)** **c)**

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.

2. Results of the Previous Semester

- A Matlab automated measurement images for a SiO_2/Si samples of 60nm,80nm and 100nm was shown.

- As a recap, only the image showing A 60nm SiO_2/Si substrate tan(Ψ) and cos(Δ) measurements for RGB spectrum is shown in figure 7.

2. Results of the Previous Semester

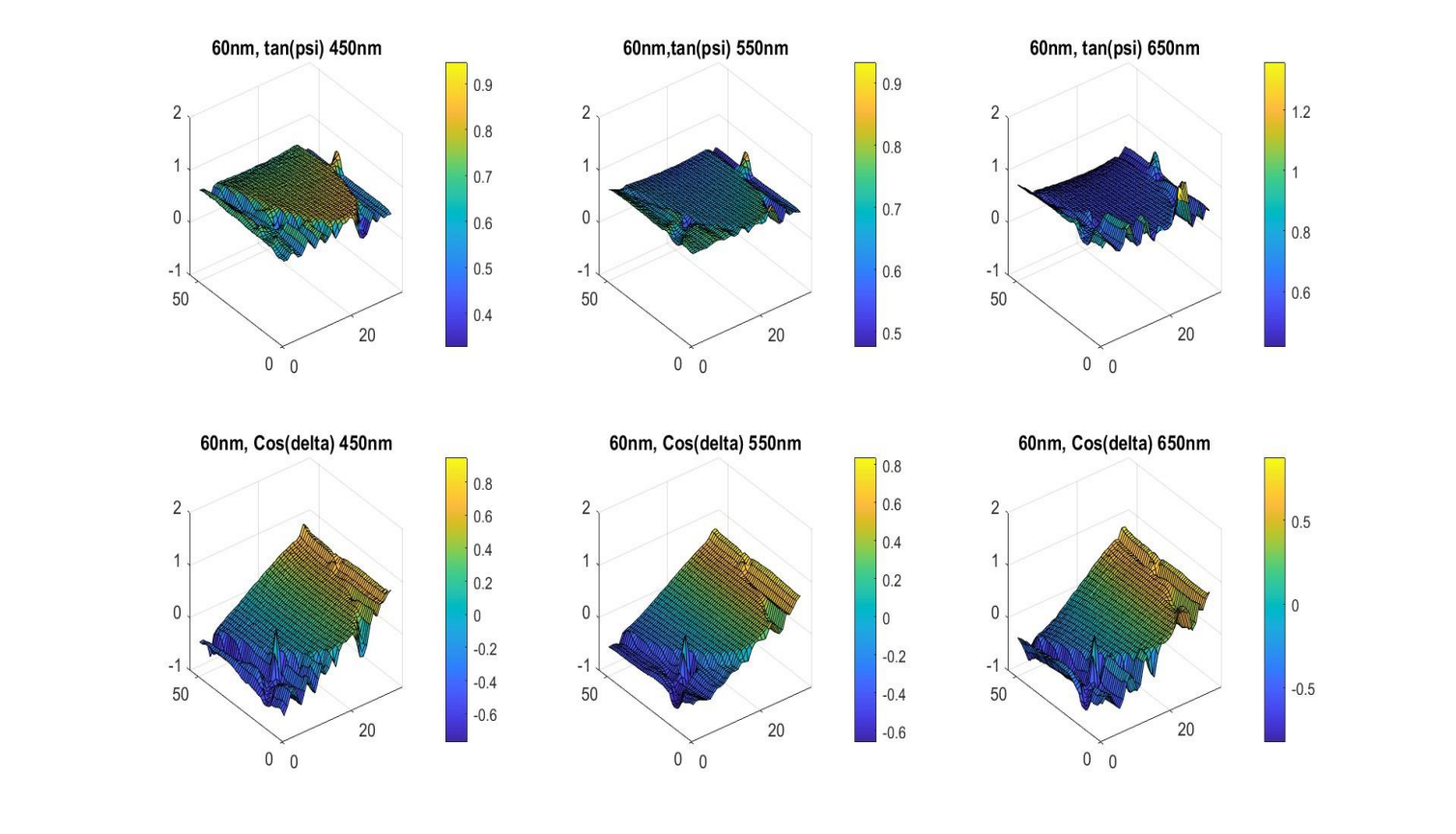


Fig. 7: A 60nm SiO_2/Si sample tan(Ψ) and cos(Δ) measurements for RGB spectrum

3. Results of the Actual Semester

- **Figure 8** and **9** show a common angle of incidence and its corresponding MSE calculated from three different samples, 40nm, 60nm and 80nm using the Matlab automation software code.

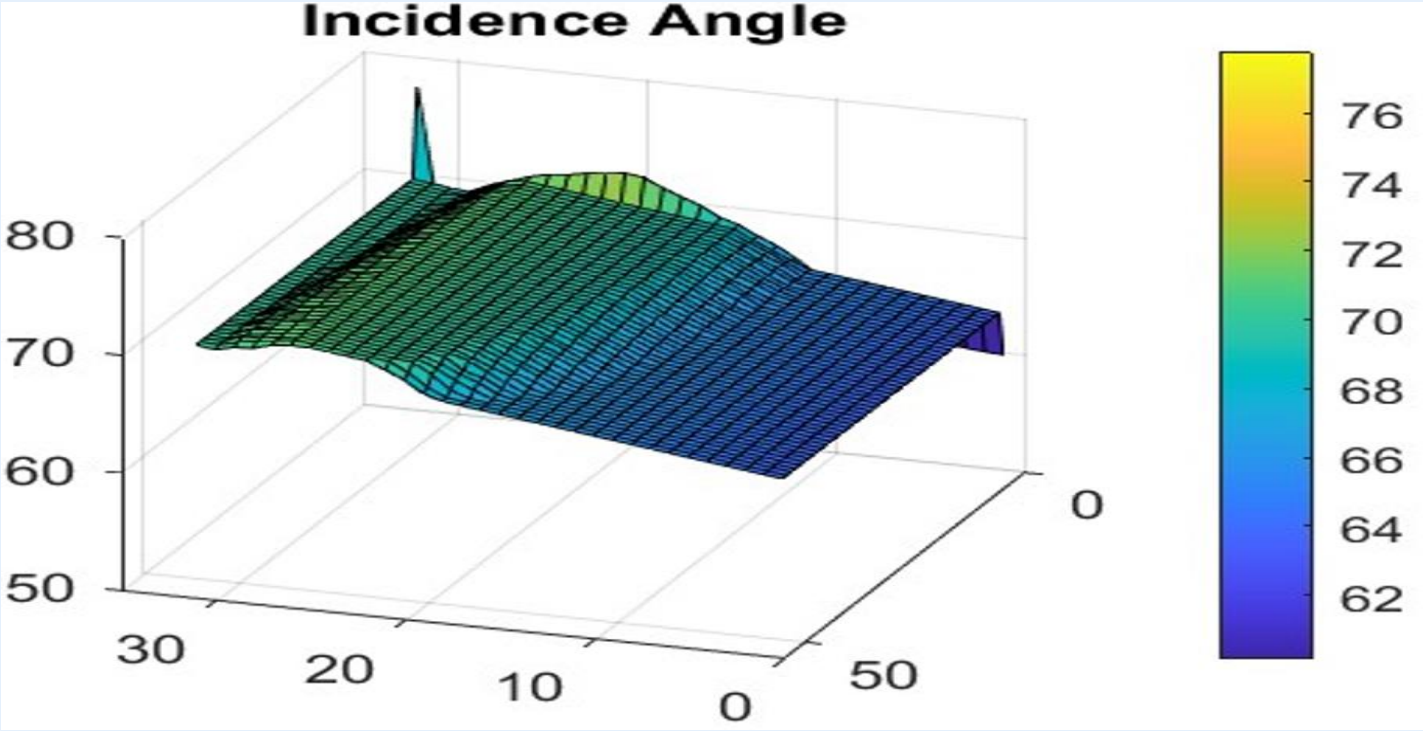


Fig 8. The common angle of incidence from 40nm, 60nm and 80nm SiO_2/Si thicknesses

3. Results of the Actual Semester

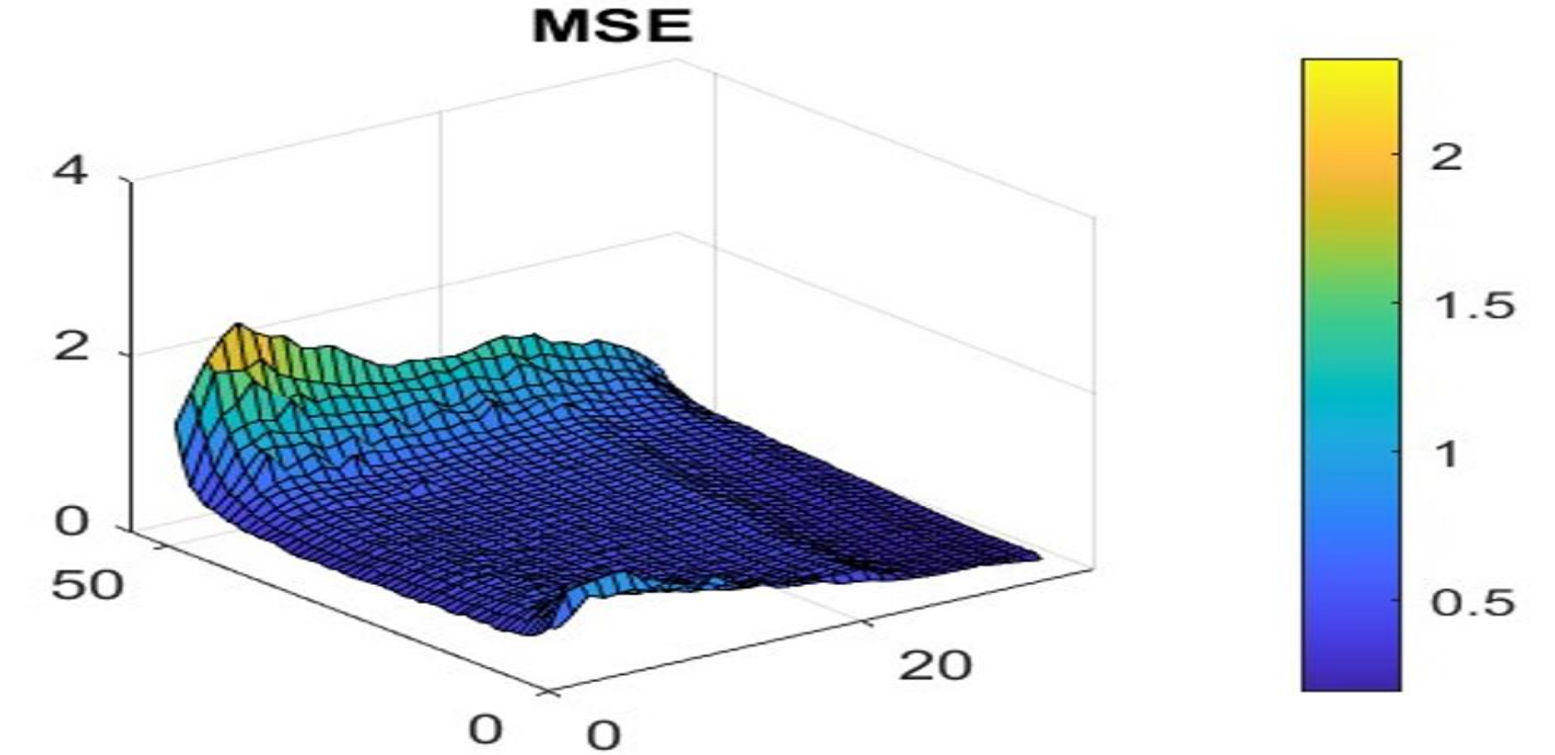


Fig 9. Common MSE values for the 40nm, 60nm and 80nm SiO_2 on Si substrate.

- The main target is to have a proper calibration of the system, and there for, these common values can be used as a reference

General View of the Prototype tool

Advantages

- The new prototype is fast imaging, around 10 times, and made up of cheap parts
- Wide mapping area up to 150cm is possible .
- No Mechanical parts

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.
- Calibration is needed.

Semester Activities

- The 9th **International Conference on Spectroscopic Ellipsometry** (ICSE) held in Beijing, China from May 22-28th, 2022. Online Presentation.
- "Carla Camp Graz- the **Photonics Career** Hub" (Photonics Austria), from 21-23 September 2022, held in the university of Graz, Austria**.**
- Symposium on Materials Science held on October 5-7, 2022
- "**XXXVII Kando Conference** 2022", Óbuda University, which was held from 3-4 November 2022
- **SPIE Photonics West**, held 28 January – 2 February 2023 in San Francisco, California, United States, ***published the paper***;

- 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)
- **26th Spring Wind Conference**, held in Miskolc, Hungary, from 5-7 May 2023.
- Participated in many online Seminars (Eg. Advanced Photonics Webinar: on Vectorial Metrics in Optics", on 14th Dec 2022, Surface Science Discussions 2024 – Programme, January 9-10, 2024, and many others.)

Publications:

Multi-color ellipsometric mapping tool from cheap parts
https://doi.org/10.1117/12.2649926 **mtmt: 33699231**
Multi-color ellipsometric mapping tool from cheap parts **ISBN: 9789634493204**
https://m2.mtmt.hu/api/publication/33751620

4. Plans For the Future Work

- We are setting up a new prototype microscopic ellipsometer imaging device, which in principle is similar to our former device.
- This new device consists of a polarizer, a monochromatic laser light source, instead of a light from LCD TV as our former imaging device.
- The advantage of this new microscopic ellipsometer imaging device is it doesn't need any mirror or window calibrations and is expected to be more precise compared to our former imaging tool but mostly will be used for smaller sample measurements.

köszönöm !