OBUDA UNIVERSITY

Doctoral School on Materials Sciences and Technologies

Institute of Technical Physics and Materials Science
Centre for Energy Research

3rd Semester Report On

‘ Non-Destructive Optical Mapping Tool From Cheap Parts ’

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

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OUTLINE

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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** correspond to the wavelength of the light beam '**λ**' and the angle of incidence of the beam '**θ**' at the sample surface.
- 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

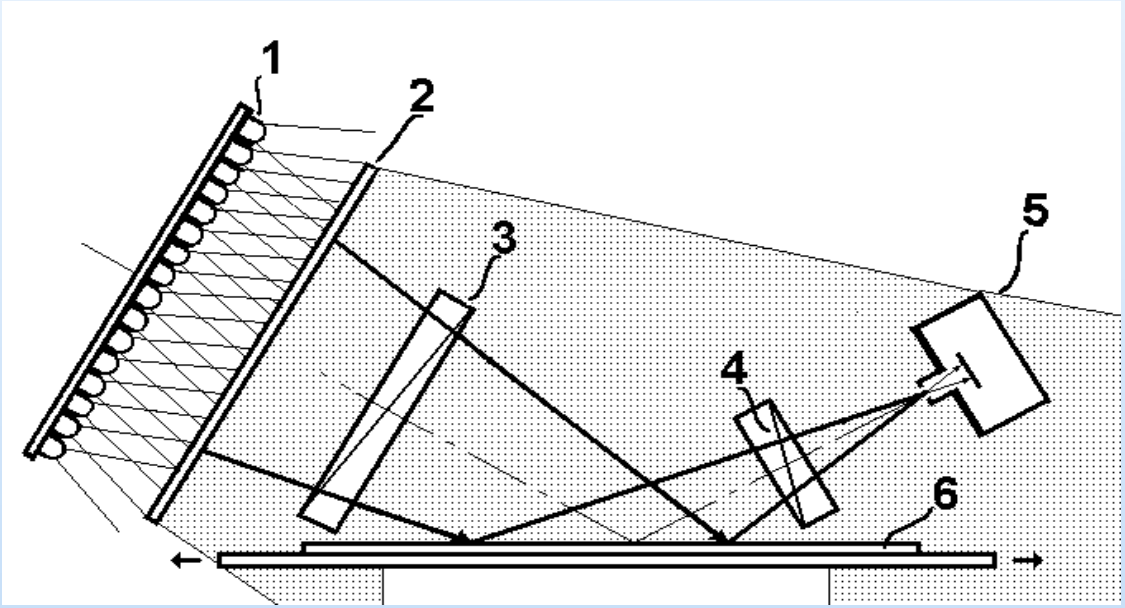


Fig. 1: Original concept of the non-collimated beam ellipsometer

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

6. Sample

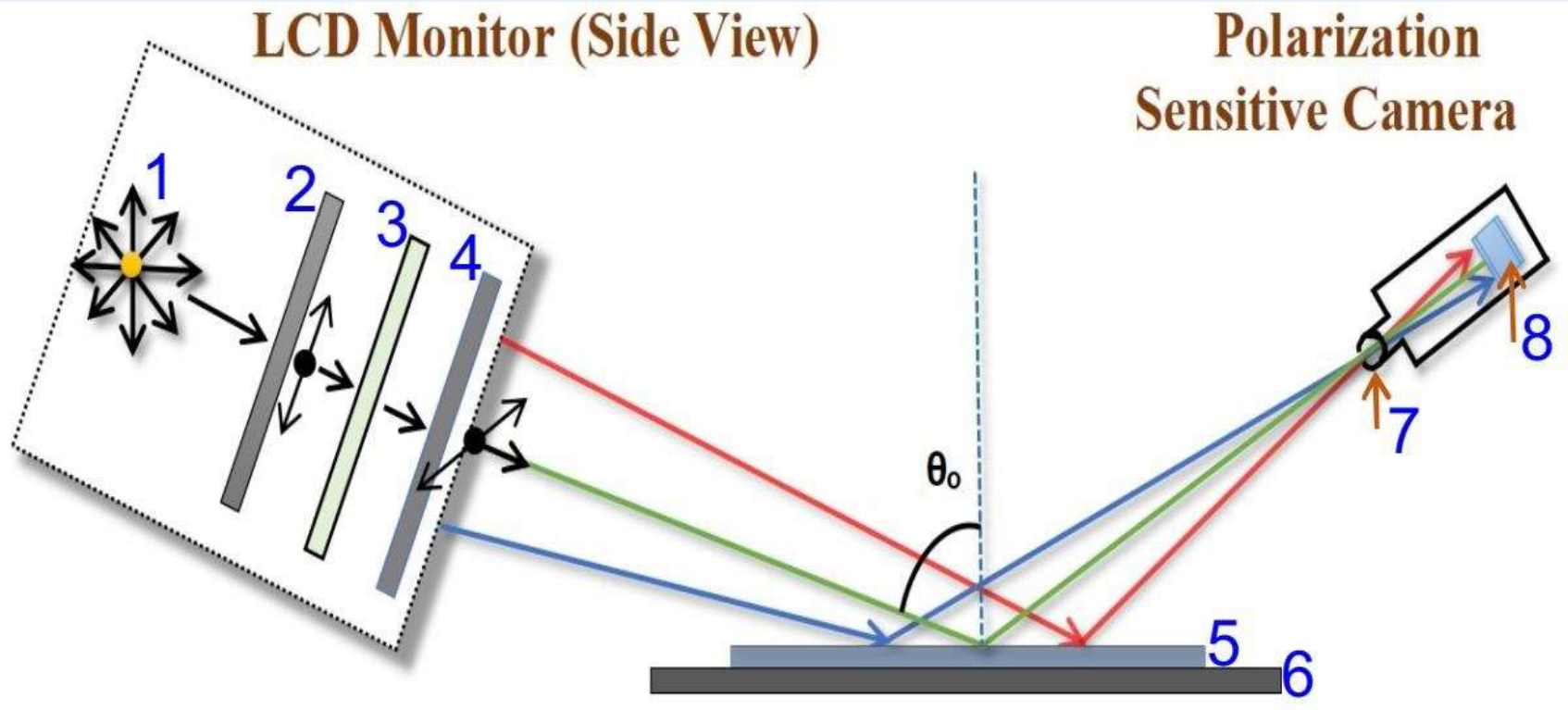


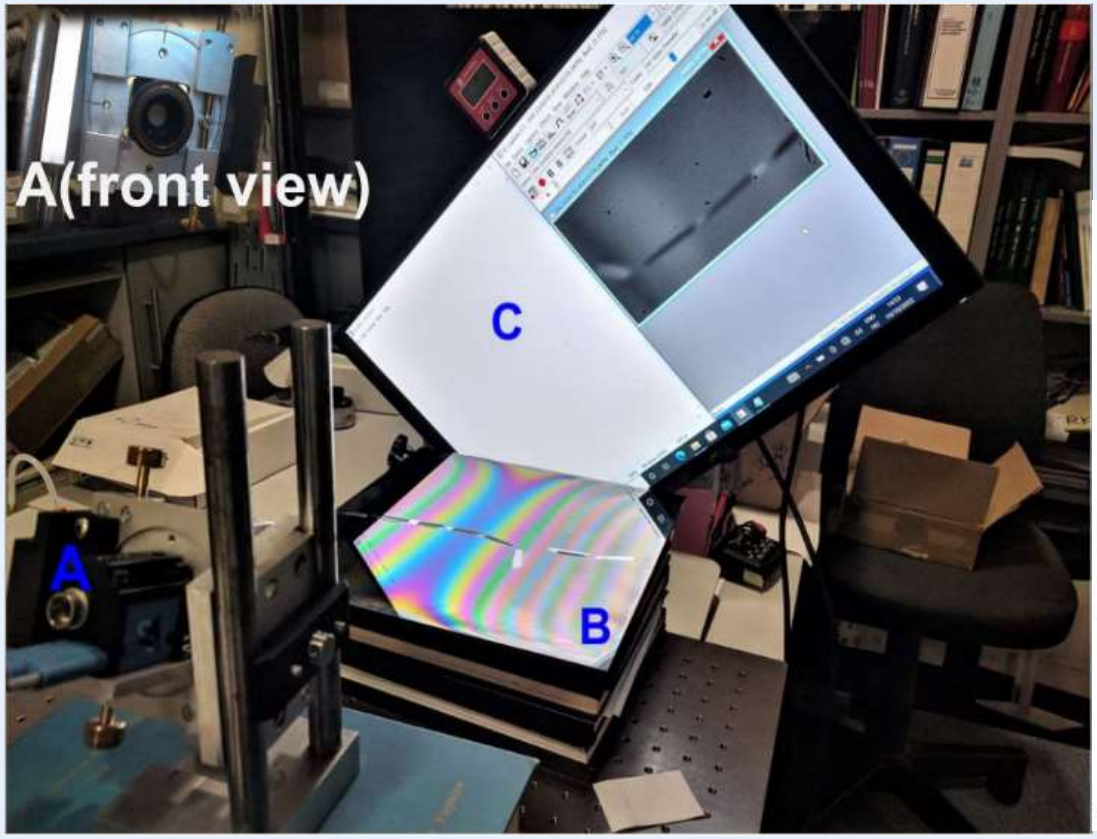
Fig. 2: New concept of the non-collimated beam ellipsometer prototype from cheap parts

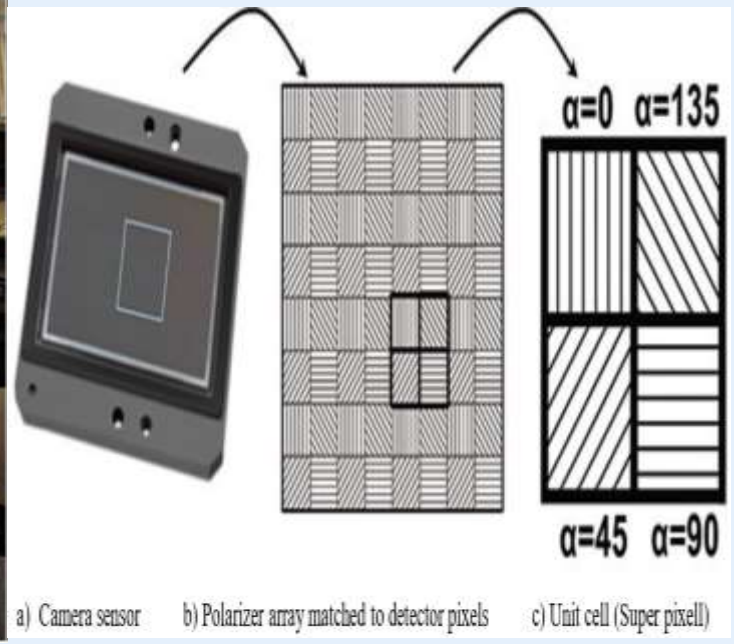
1) Light source **2)** Vertical polarizer **3)** Liquid crystal cell

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

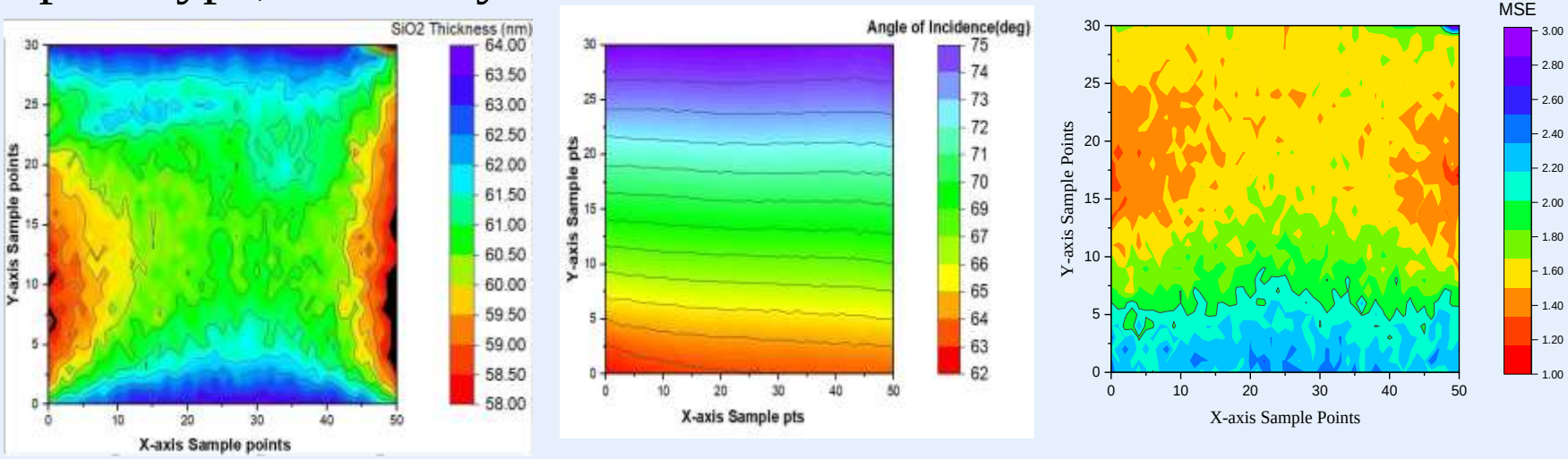
- **Fig. 4**: Rotating Compensator Spectroscopic Ellipsometer (M2000DI)
- The M2000DI ellipsometer is used for control measurements.

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

3. Results of the Actual Semester

Actual Semester Aim :

Calibration of the prototype imaging tool from different positions and preliminary analysis of WO_3-MoO_3 combinatorial mixed layers on a 30x30 cm glass sheet.

- **First step**: **AOI** calibration using SiO_2/Si sample by
  - Placing the oxide sample at three different positions
  - Measuring the **AOI, MSE**
  - Choosing the points of lower MSE values and
  - Developing single map calibration of the MSE and **AOI**
- **Second Step**:

Preliminary analysis of WO_3-MoO_3

Analysis : Thickness, EMA

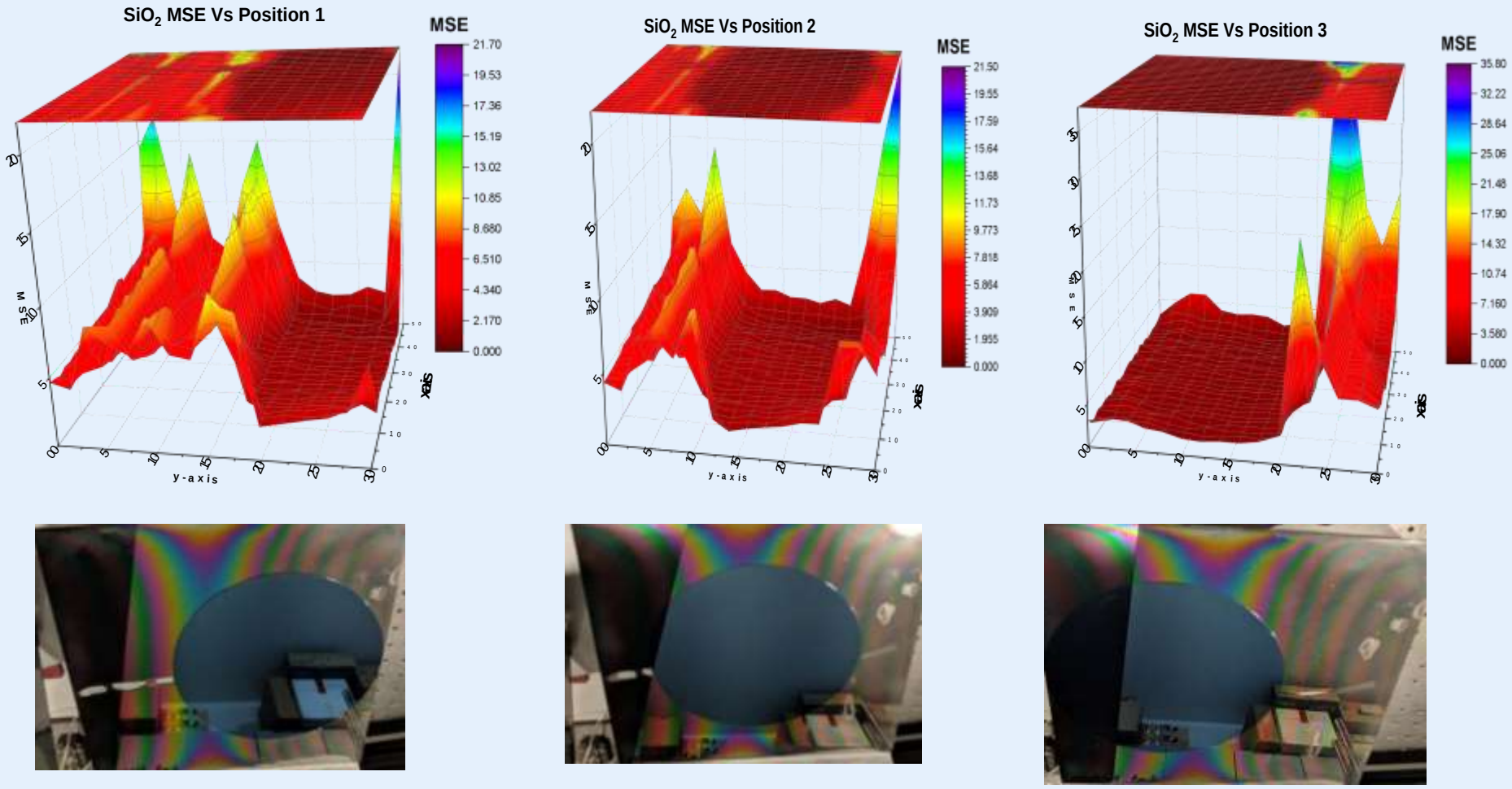
(Effective Medium Approximation)

from the AOI calibration

Fig. 6: WO_3-MoO_3 Sample

3. Results of the Actual Semester

3.1 SiO_2 MSE calibration

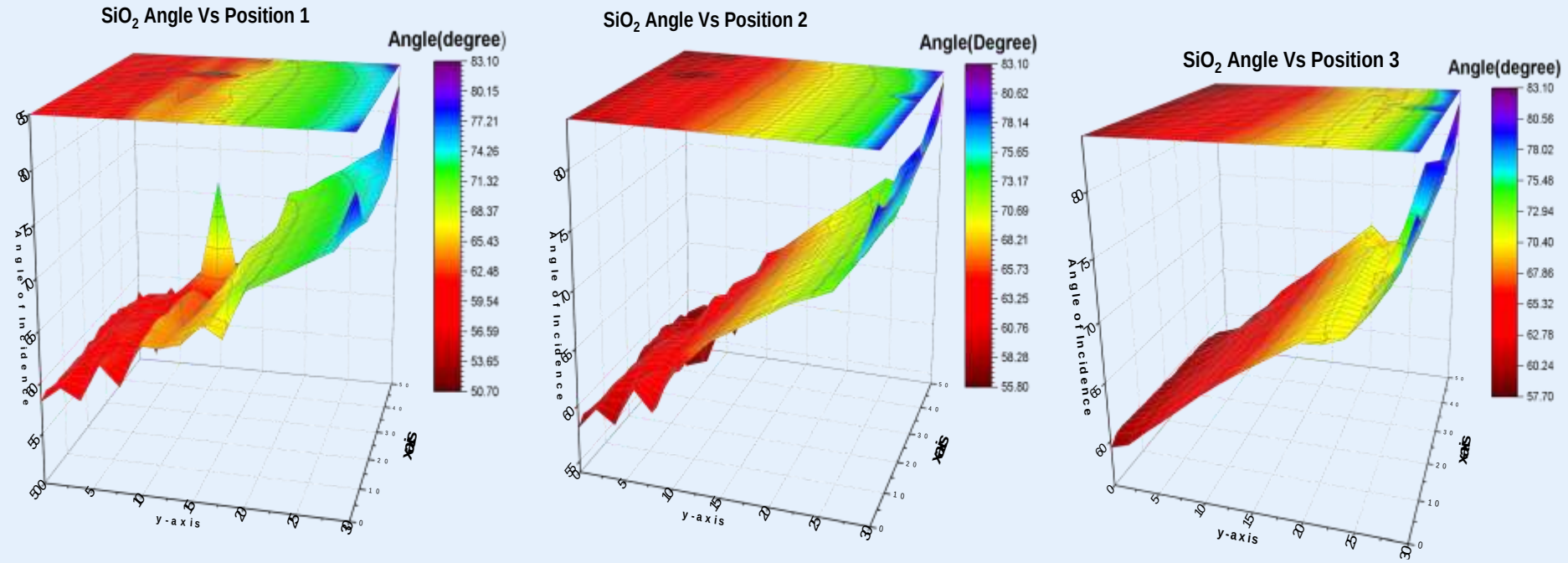


a) **b)** **c)**

Fig. 7: 3D maps of the MSE values of SiO_2 vs Positions 1,2 and 3 respectively.

3. Results of the Actual Semester

3.2. SiO_2 thickness calibration

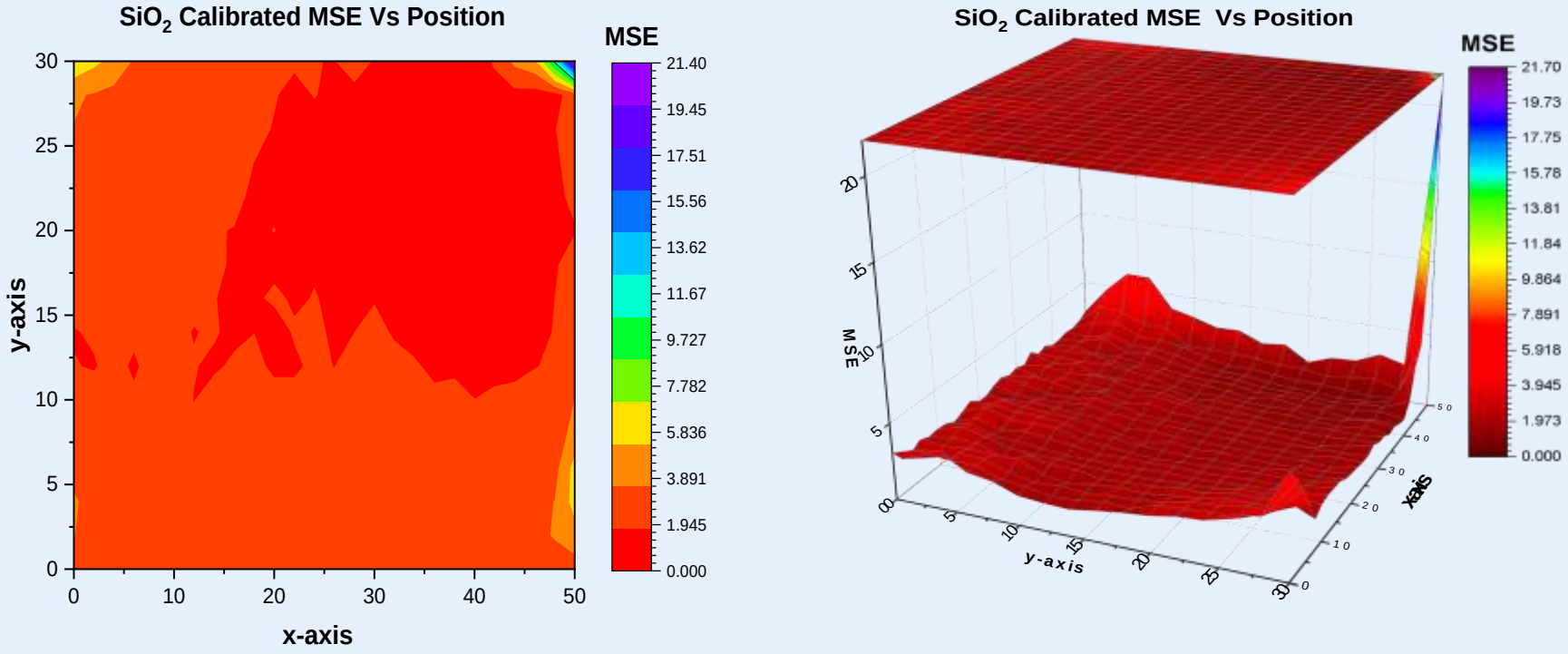


a) **b)** **c)**

Fig. 8. 3D map of the angle of incidence values from three different positions 1,2 and 3,respectively

3. Results of the Actual Semester

3.3. Calibrated MSE, SiO_2

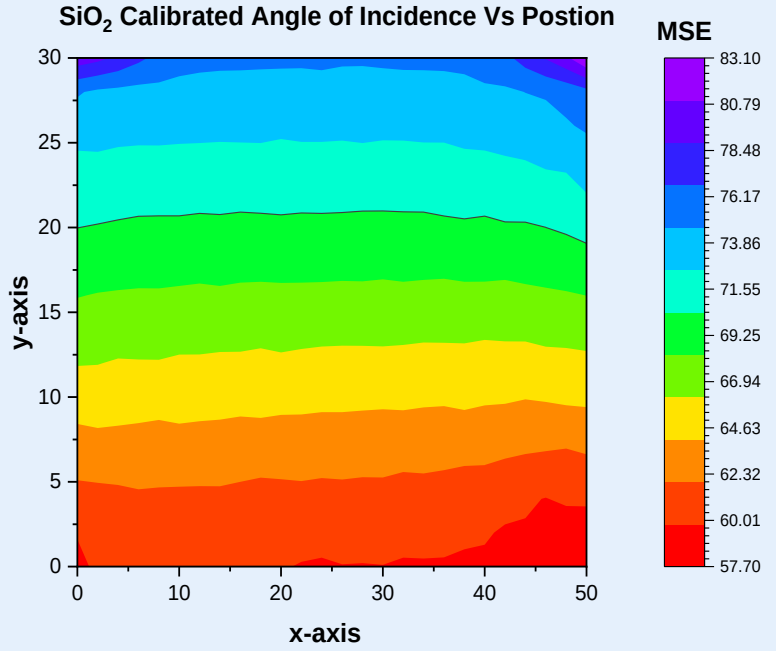


a) **b)**

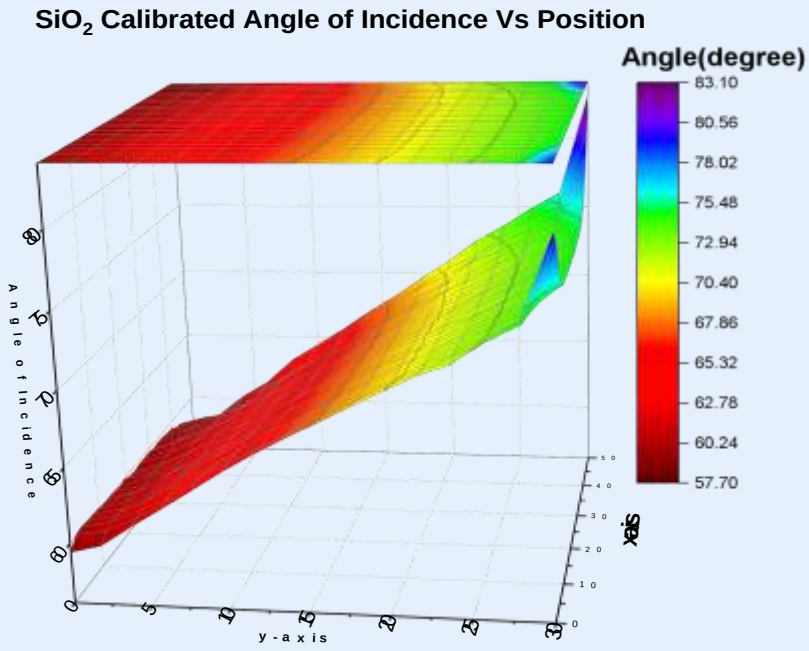
Fig. 9. 2D and 3D map of the MSE calibration vs Position ,respectively

3. Results of the Actual Semester

3.4 Calibrated thickness , SiO_2



a)

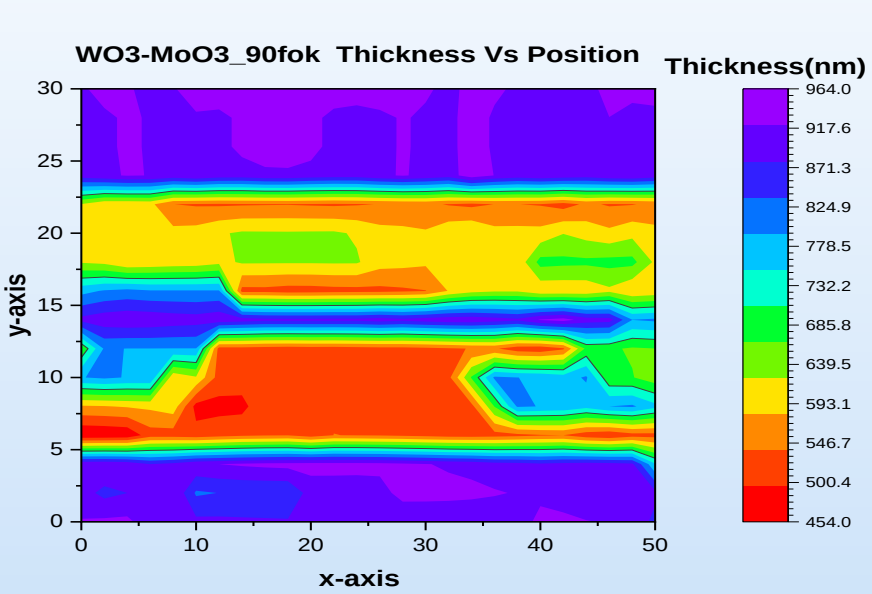


b)

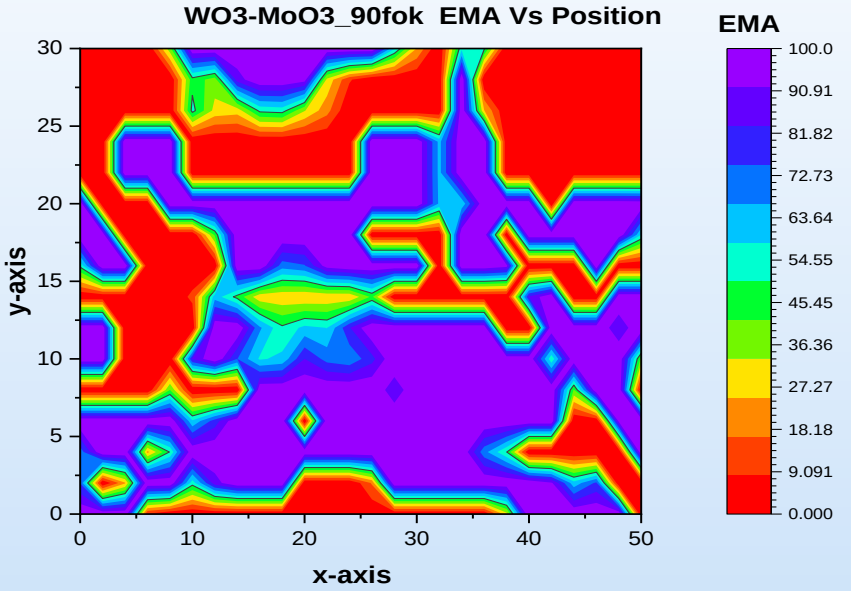
Fig. 10. 2D and 3D map of the angle of incidence values vs Position ,respectively

3. Results of the Actual Semester

3.5 WO_3-MoO_3 Measurements



a)



b)

Fig. 11: WO_3-MoO_3 thickness and EMA vs Position, respectively.

- WO_3-MoO_3 is mostly transparent to the visible light range, hence resulting higher errors on the maps above.
- The Imaging prototype is very sensitive within the visible range.

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.

Activities

Table 1. Courses completed in this actual semester

Course Neptun Code	Course Title	Instructor	Cr. Pts.
OATBGEN1ND	Band gap Engineering	Dr. Nemcsics Ákos	6
OATNOMK1ND	Numerical methods for the evaluation of optical measurements	Dr. Petrik Peter	6
OATSZFA1ND	Solid-state light sources and their application	Dr. Zsolt Jozsef Horvath	6
OATBESZ3ND	Research report III	Dr. Recskiné Dr. Borsa Judit Ilona	6
QATKUTP3ND	Research project III.	Dr. Recskiné Dr. Borsa Judit Ilona	10
		Semester Total Cr. pts	34

Activities

Conferences

- "**Carla Camp Graz- the Photonics Career Hub**" (Photonics Austria), University of Graz, Austria**,** on 21-23 September 2022
- "**XXXVII Kando Conference 2022**", Obuda University, on 3-4 Nov. 2022
- **Online webinars**, "Advanced Photonics Webinars '' on Vectorial Metrics in Optics", on 14th Dec 2022, and others.

Publication

- **Accepted publication**:

Submission TSF-D-22-00891R1

Title, "*Non-destructive optical imaging tool from cheap parts*"

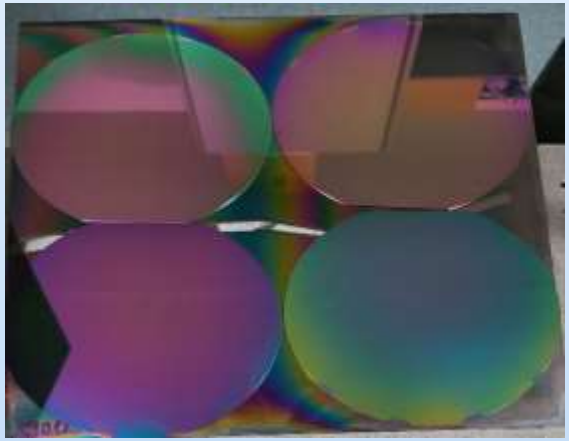
Berhane Nugusse; György Juhász; Csaba Major; Péter Petrik; Sándor Kálvin; Zoltán György Horváth; Miklos Fried

Thin Solid Films, VSI:ICSE-9

4. Plans For the Future Work

- Different samples, Poly silicon samples, will be considered to further cross check the precision, sensitivity and range and limits of the prototype for a better and broader scope and understanding of the optical mapping tool.

Fig. 12: Poly Si samples



- The Wollam M2000 ellipsometer will be used for control measurements

köszönöm !