Confocal Raman Characterization of Sputter coated TiO_2 Nanotubes on Functional Substrates

Simcelile Zinya

(201210029)

Supervisor: *Prof. Edson L. Meyer*
Co-supervisor: *Dr. Raymond T. Taziwa*
Co-supervisor: *Dr. David M. Katwire*

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Outline

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Introduction

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- Energy demand has intensified research on renewable energy sources.
- Efforts have been devoted to develop high efficient solar cell devices.
- Dye sensitized solar cells (DSSCs) are deemed as the most promising candidates, which commonly use TiO_2-NPs as photo-anode.

Background

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- Random connections in TiO_2-NPs, bring about charge recombination.

- TNTs-FS may stimulate DSSCs due to vectorial charge transport and charge collection efficiencies.

- Complexity in fabricating highly conductive thin film, limit the application of TNTs in DSSCs.

Background

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- This study focuses on synthesis and CRS characterization of TNTs on functional substrate.

- Hence, it will allow a more qualitative study and understanding of TNTs structural properties.

Aim & Objectives

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- **Aim**
  - Synthesis of TNTs on FTO glass substrate using electro anodization technique and CRS characterization of TNTs.
- **Objectives**
  - To evaluate the structural and morphological properties of TNT annealed at different temperatures using SEM and XRD
  - To evaluate the structural phase distribution of TNT using Confocal Raman Spectroscopy through Large Area Scans and Depth profiling.

Methodology

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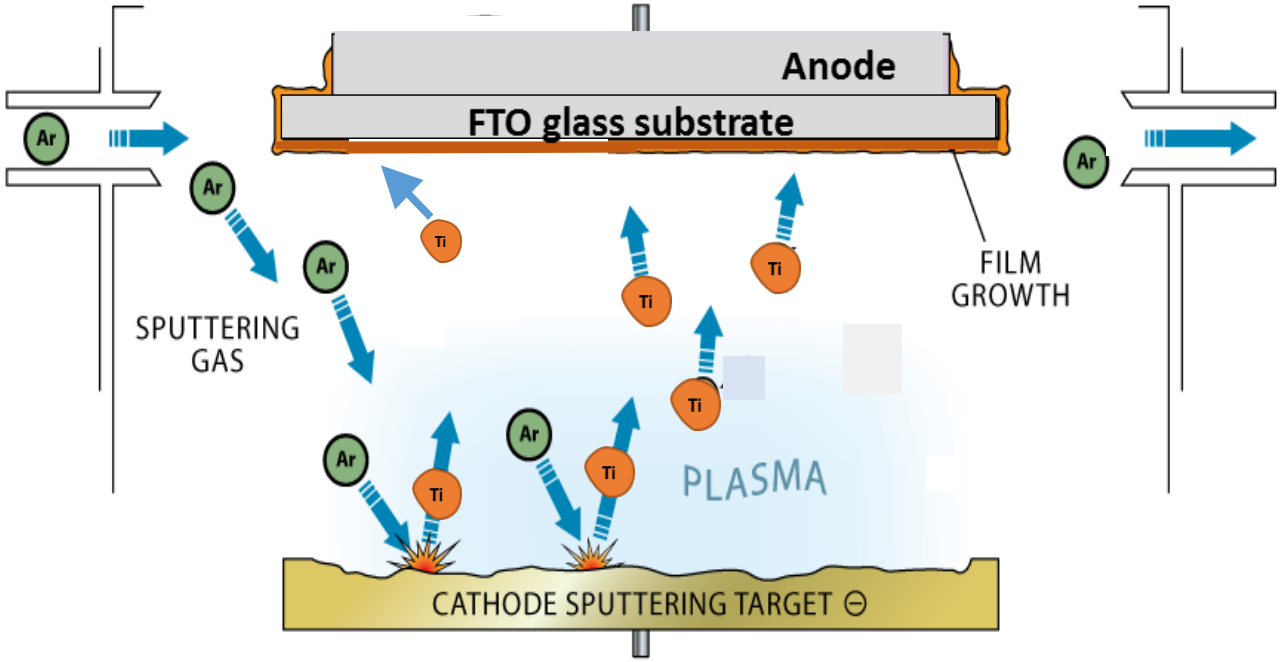
RF SPUTTERING PROCESS



SPUTTERING CONDITIONS

- RF power - 150W
- Pressure - 39 mbar
- Temp - 200 °C
- Period - 4 hours
- Thickness - 10 µm

Experimental setup

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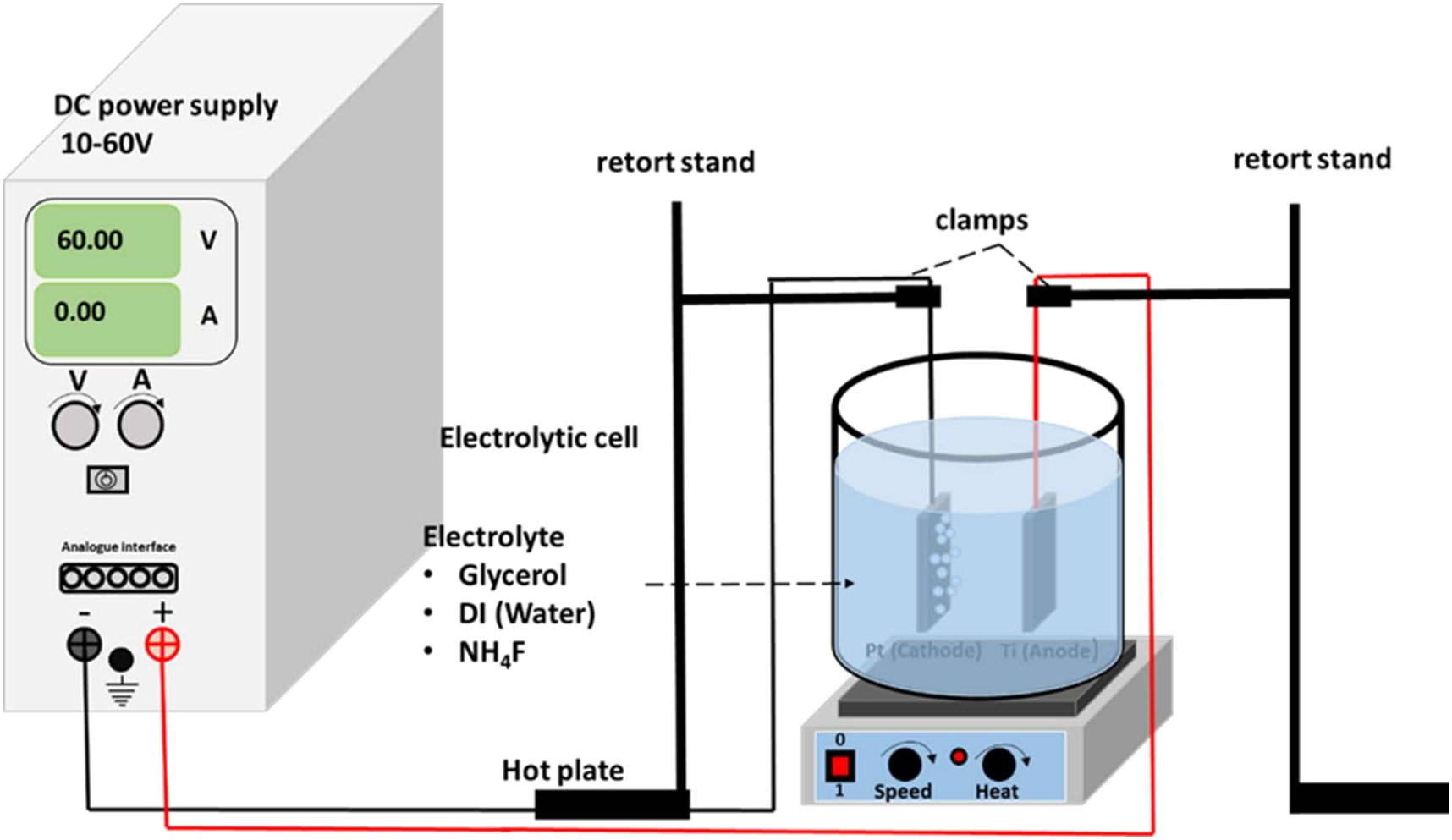

Electro-anodization

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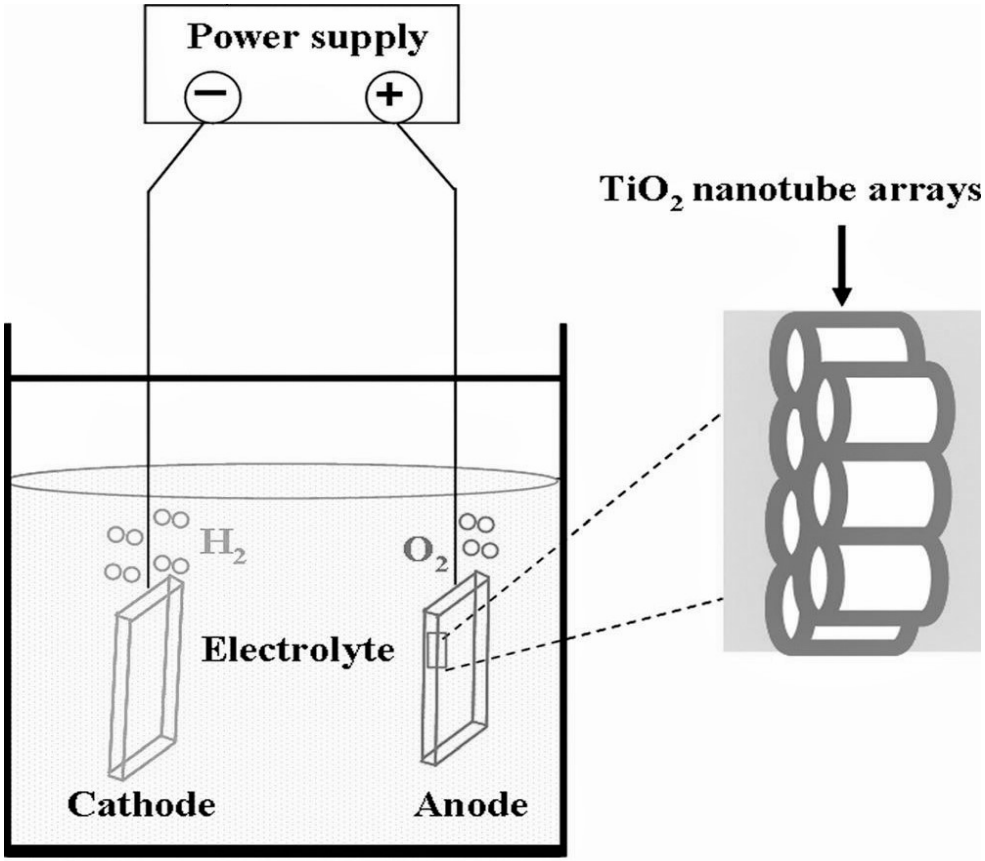

Reactions at anode:

1. $Ti \rightarrow Ti^{+4} + 4e^-$
2. $Ti^{+4} + 2H_2O \rightarrow TiO_2 + 4H^+$
3. $TiO_2 + 4H^+ + 6F^- \rightarrow [TiF_6]^{-2} + 2H_2O$

- Anodization of Ti occurs as a result of the competition between oxide formation and chemical dissolution of the oxide by F^-.

Methodology

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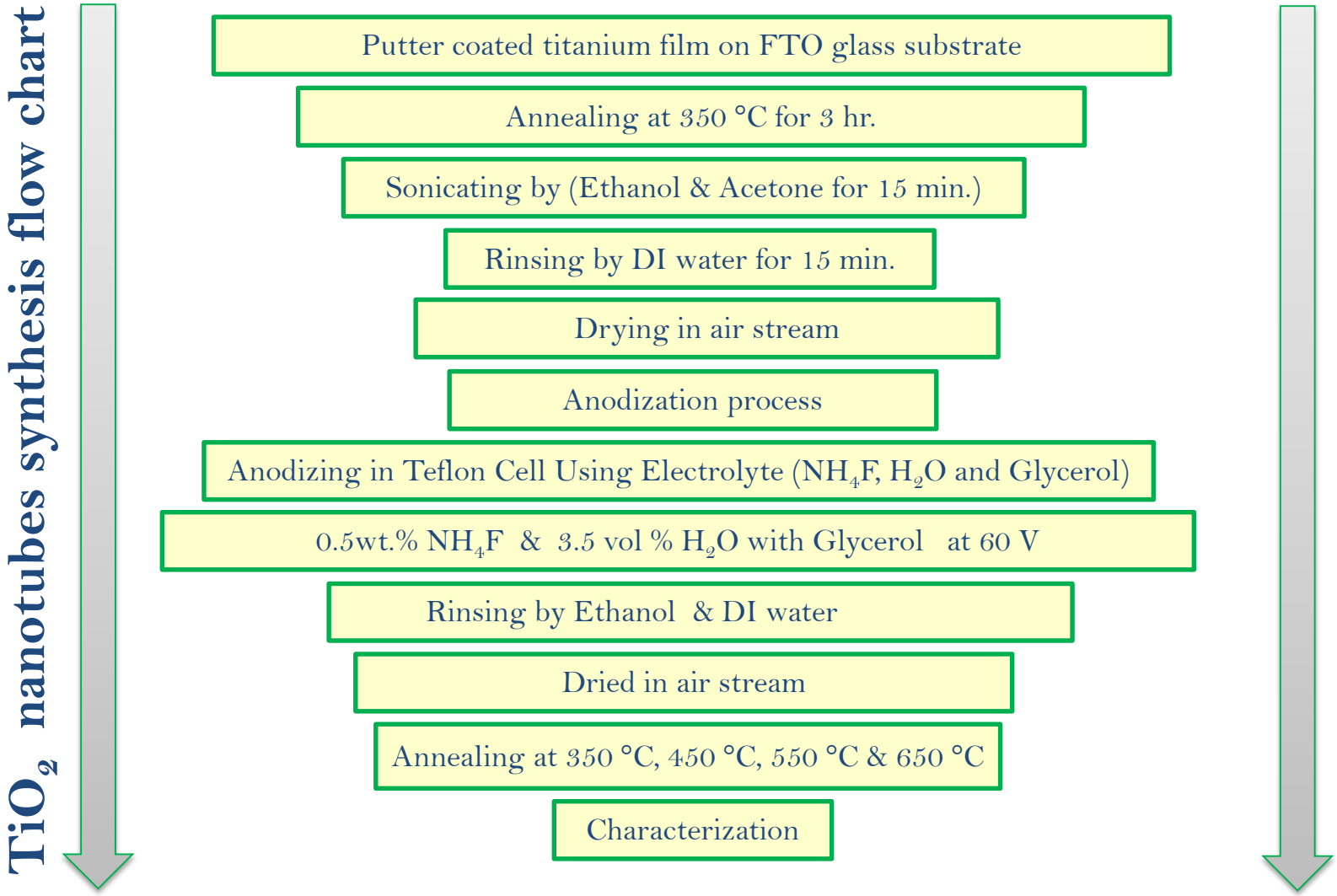

Characterization techniques

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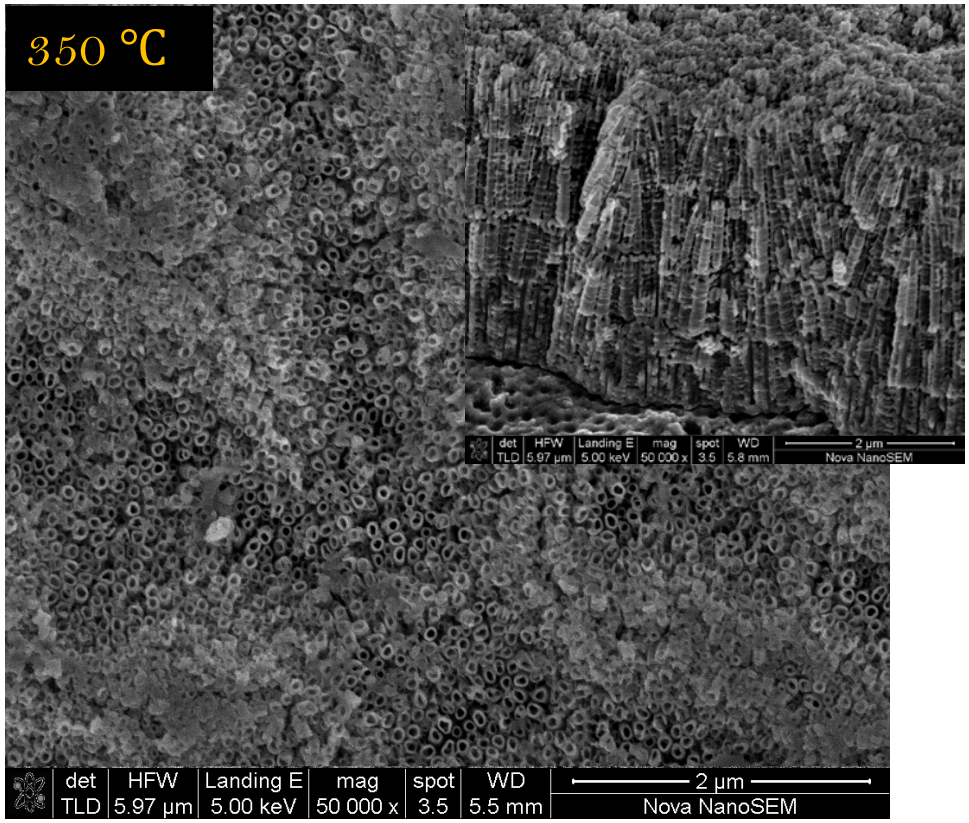
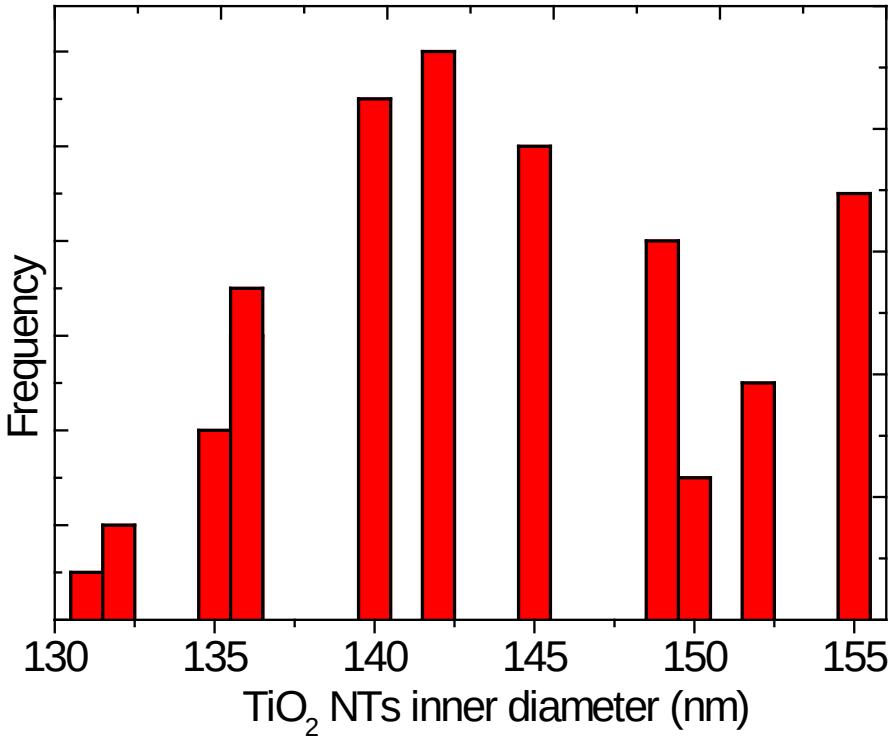
- The following techniques were used to determine the structural and morphological properties TNTs grown on FTO glass substrate.

  - Scanning Electron Microscopy
  - X-ray Diffraction
  - Confocal Raman Spectroscopy
    - Large area scan
    - Depth profiling

Results : SEM





- SEM micrographs have revealed regular TNTs covered by barrier oxide layer.
- Pore diameter of TNTs are in the range of 130- 155 nm.

Results : SEM

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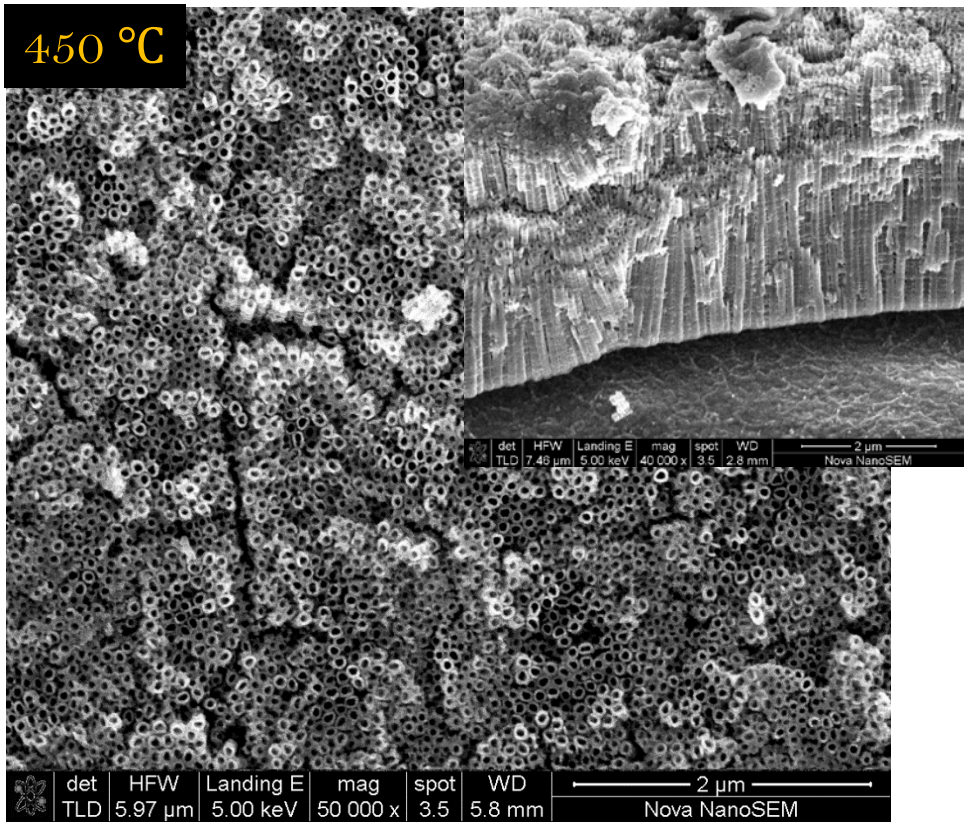
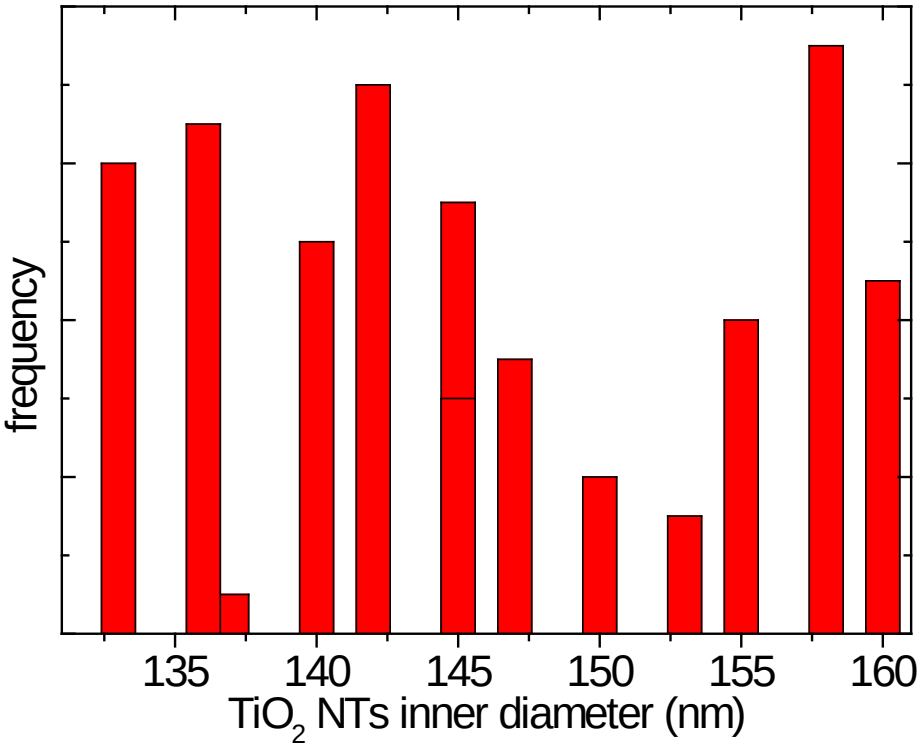
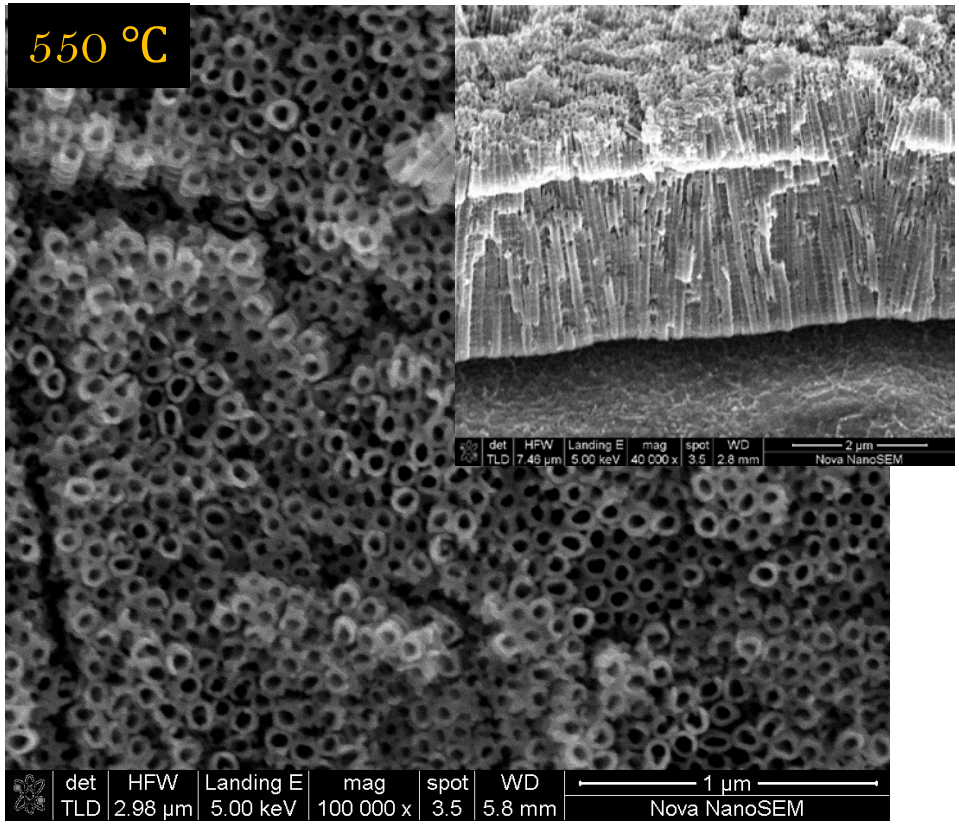
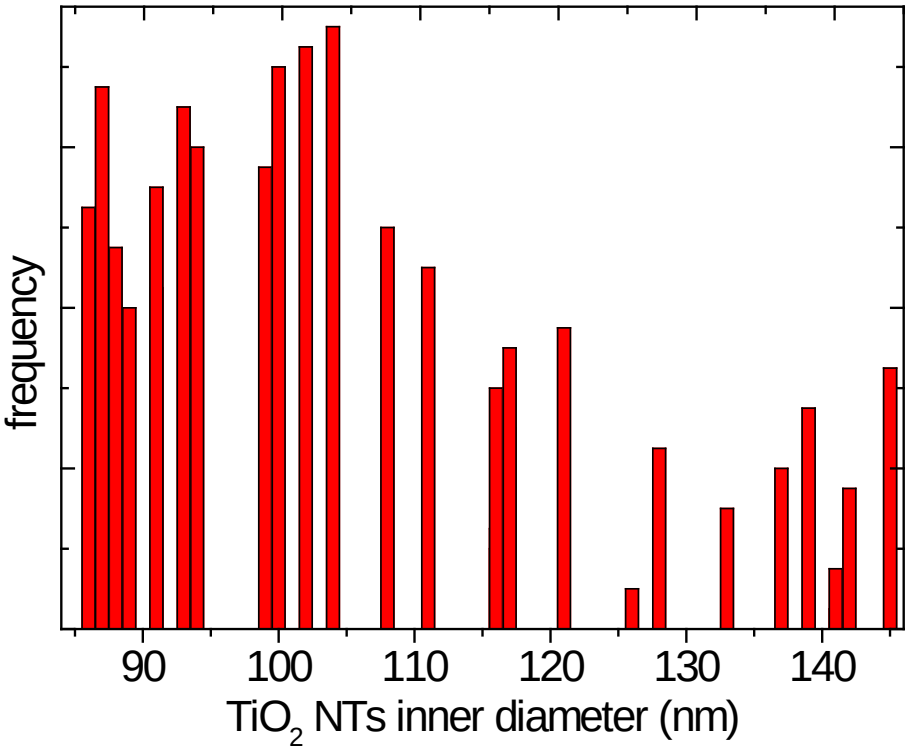




- Well orientated surface morphology of TNTs on FTO glass substrate.
- Increased TNT inner diameter size (150- 170 nm).

Results : SEM





- Cross sectional view shows smooth & well aligned TNTs.
- Increase in temperature results in greatly enhanced morphology of TNTs.

Results : SEM

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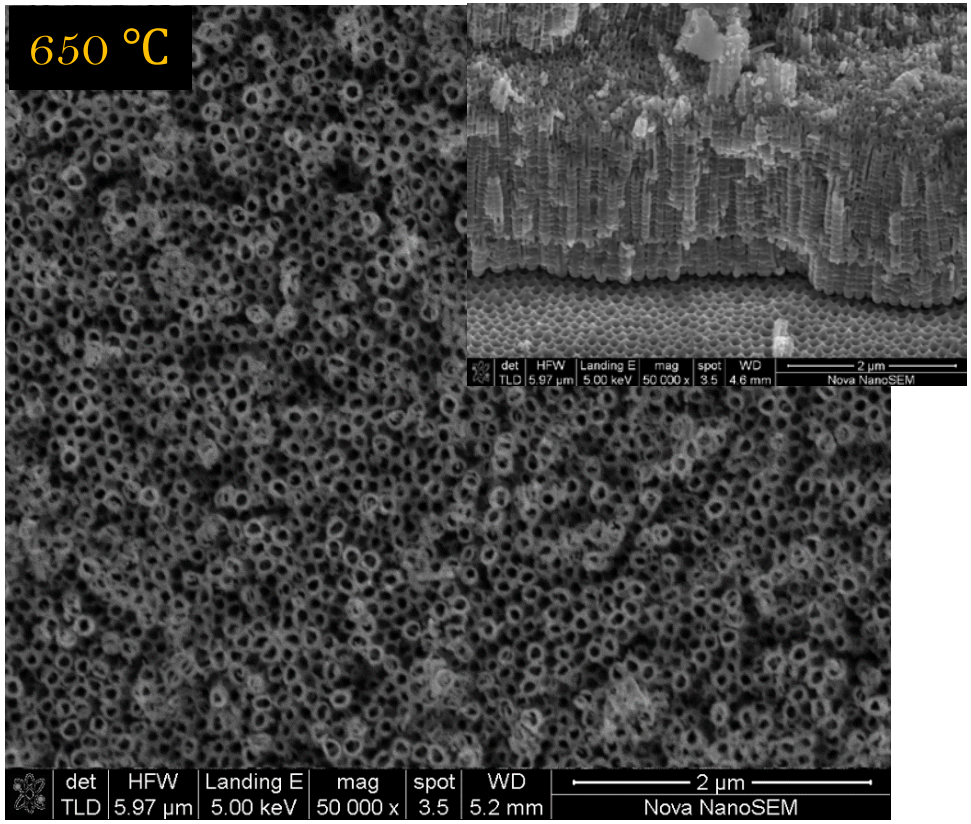

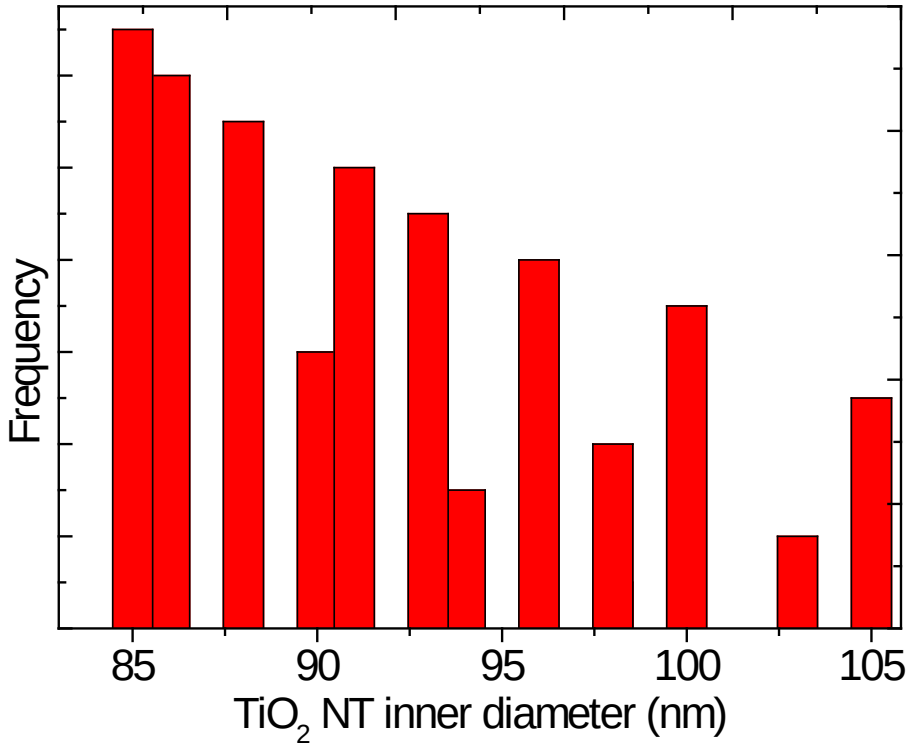

- SEM revealed orientated surface morphology of TNTs grown on FTO glass substrate.
- No morphology disruption or deformation observed of TNTs at 650 °C.

Results : XRD

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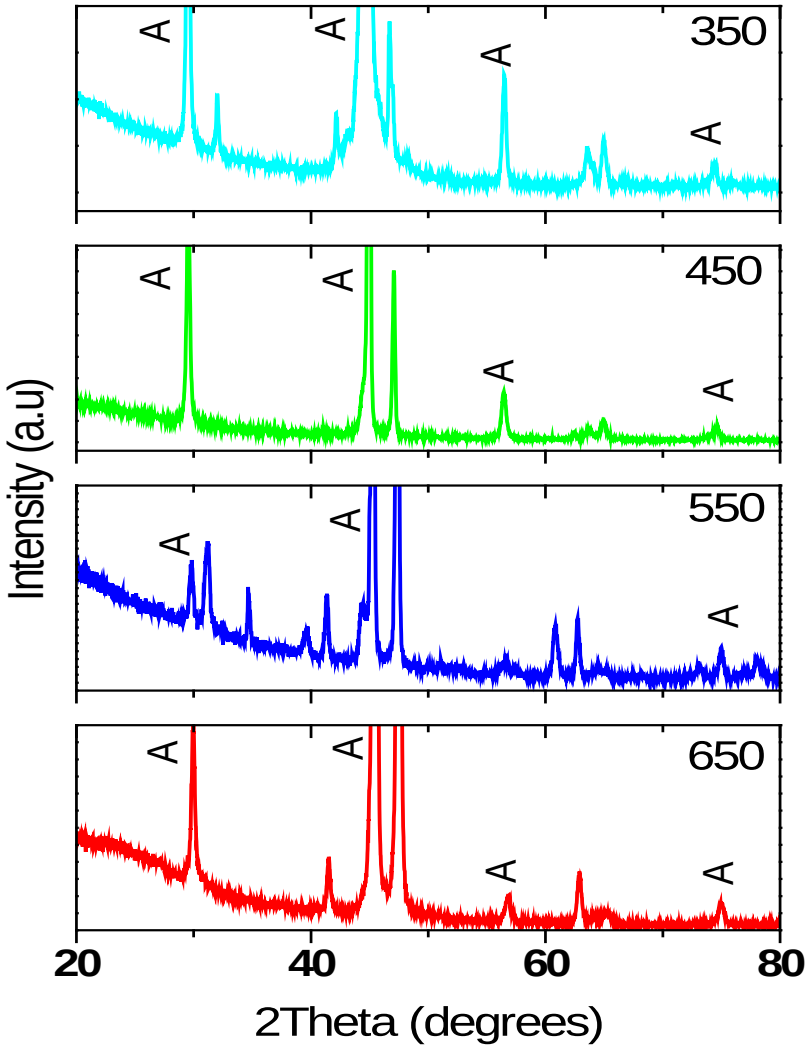
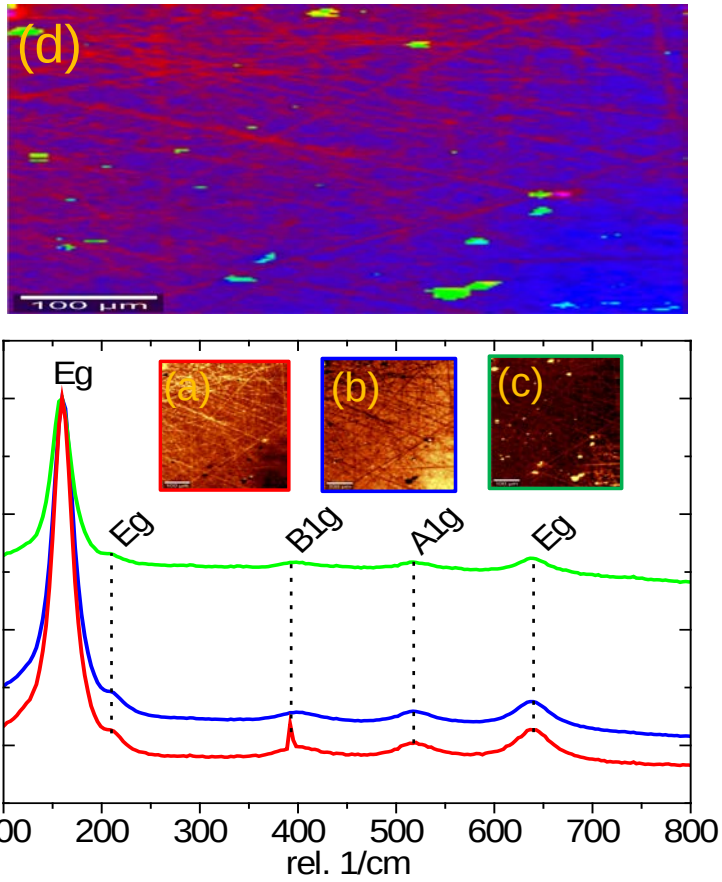
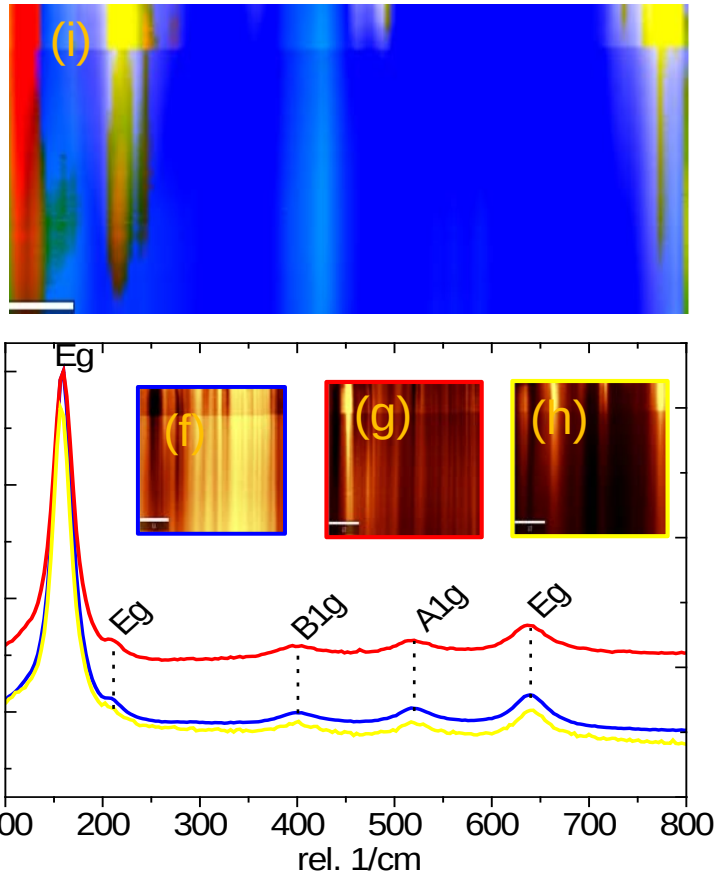


Results : CRS



LAS (XY) TNT 350 °C



Depth (XZ) TNT 350 °C

Results : CRS

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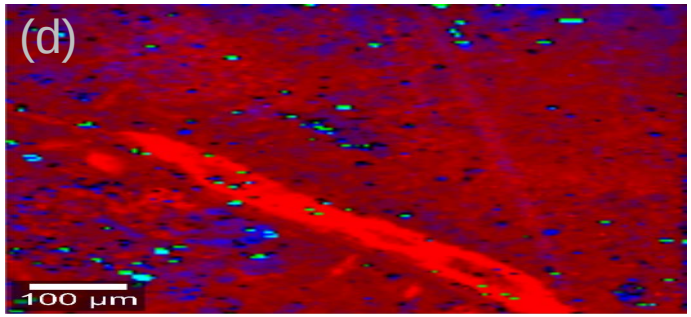

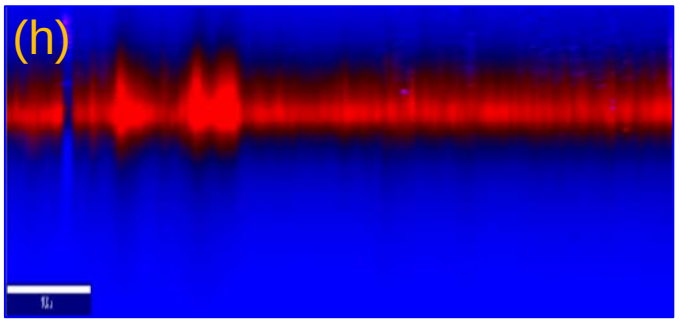

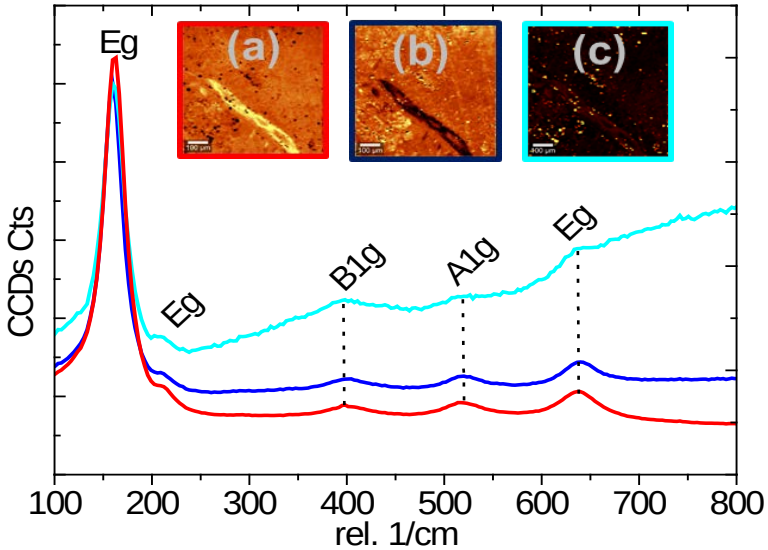

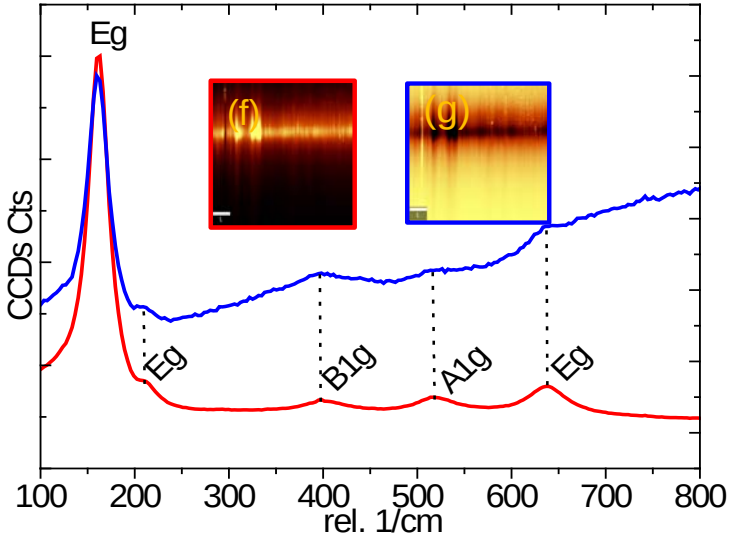

LAS (XY) TNT 450 °C

Depth (XZ) TNT 450 °C

Results : CRS

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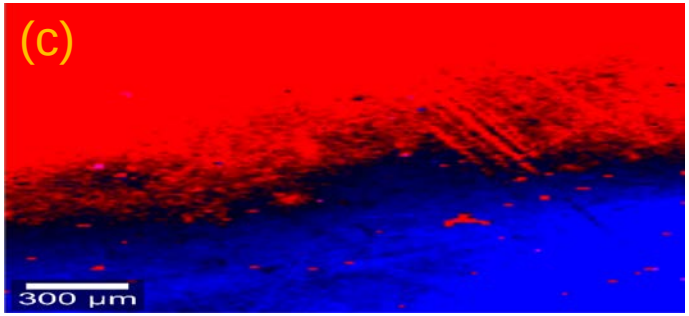
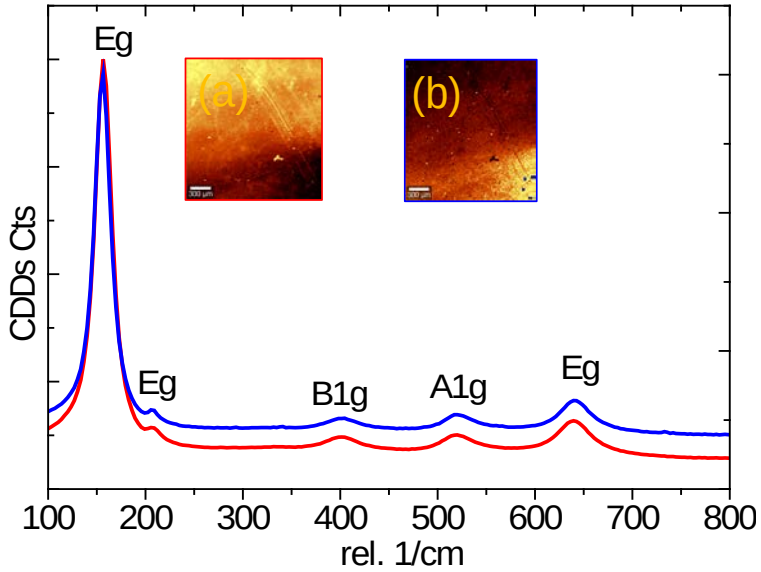
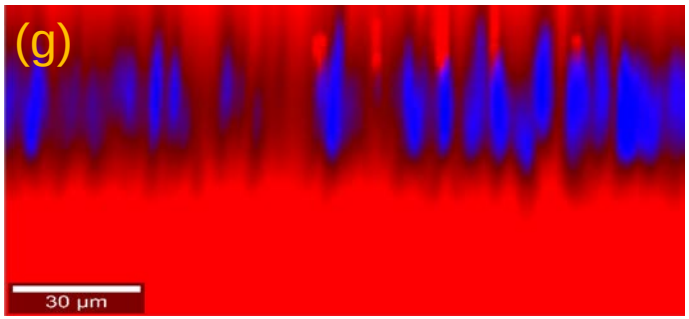
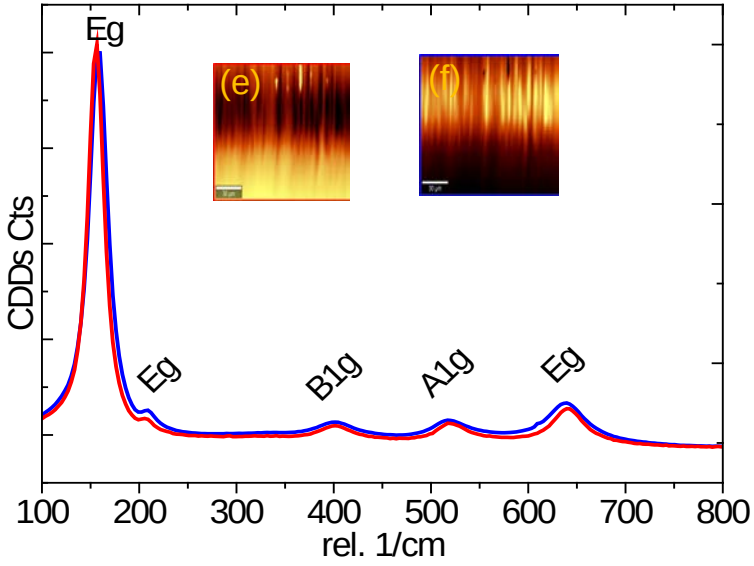




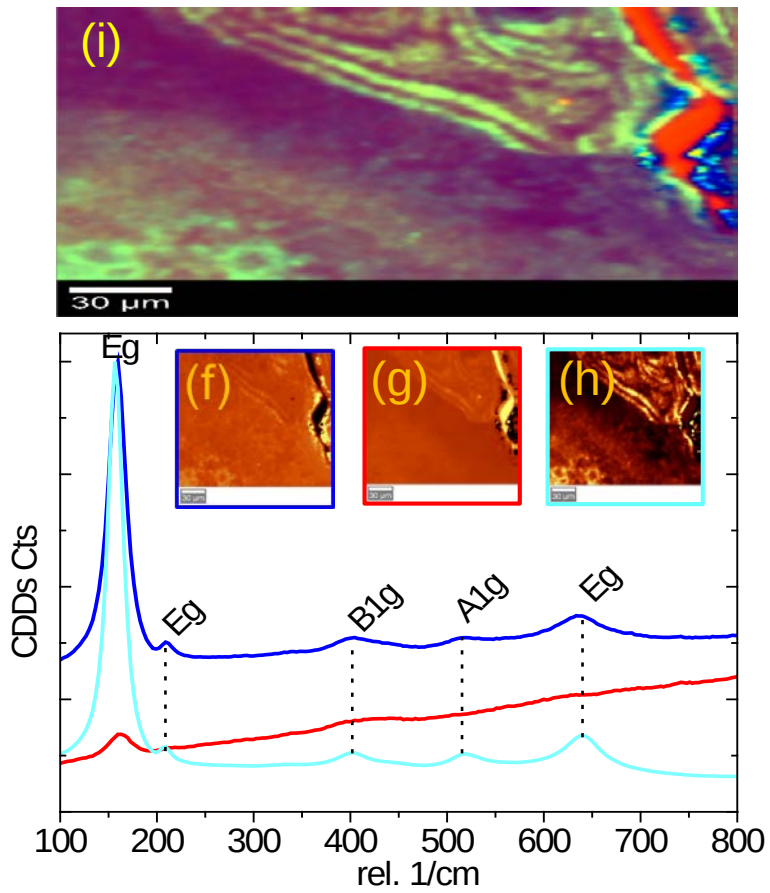
LAS (XY) TNT 550 °C



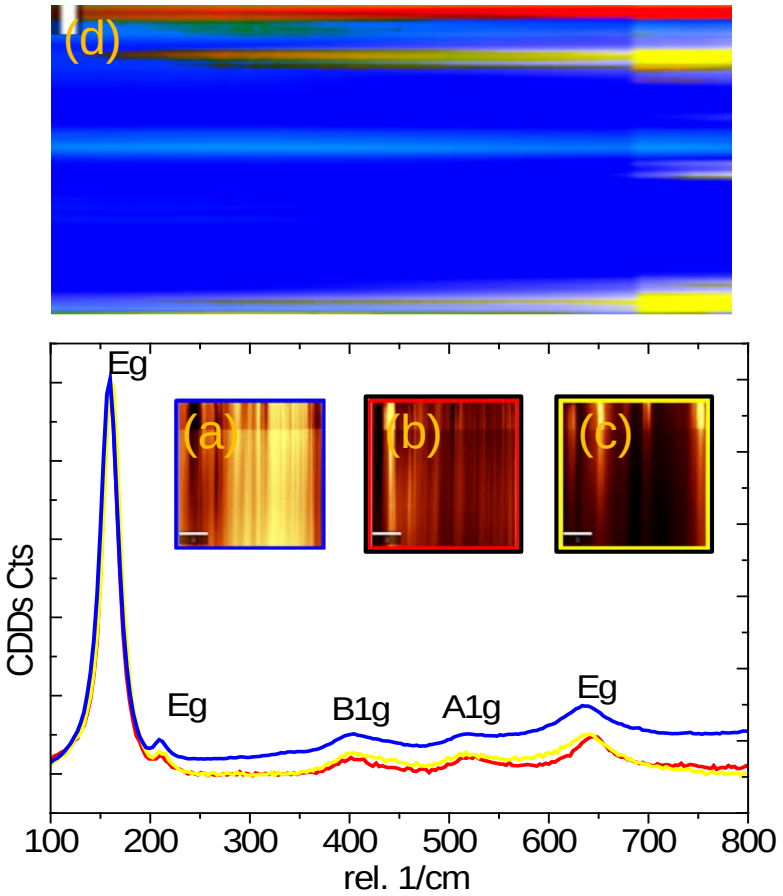


Depth (XZ) TNT 550 °C

Results : CRS



LAS (XY) TNT 650 °C



Depth (XZ) TNT 650 °C

Conclusion

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- TNT arrays with a thickness of ±10 µm and a pore diameter range 85 – 170 nm were successfully grown on transparent conductive FTO substrates by anodizing the sputtered Ti films.

- SEM micrographs show the regular morphology with no disruption or deformation of TNTs on FTO substrate even at elevated temperature (550 °C & 650 °C).

- CRS analysis (LAS & Depth) & XRD confirmed the presence of Anatase TNTs on FTO glass substrate with increase in temperature resulting in high peaks intensities, thus high structural phase maturity.

- The enhanced morphology & presence of only Anatase phase TNTs make these substrates suitable for DSSCs.

Acknowledgements

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