European Network on New Sensing Technologies for Air Pollution Control and Environmental Sustainability - *EuNetAir*

COST Action TD1105

Final Meeting at PRAGUE (CZ), 5-7 October 2016

New Sensing Technologies for Air Quality Monitoring

Action Start date: 01/07/2012 - Action End date: 15/11/2016 - EXTENSION: 15/11/2016

Gas sensors based on CuO-TiO2 heterostructures

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GEBZE TEKNİK ÜNİVERSİTESİ

Zafer Ziya ÖZTÜRK

Function in the Action (MC, WG1&2, SIG II member)

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41400 Kocaeli, TURKEY

cost EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

EuNetAir

European Network on New Sensing Technologies for Air-Pollution Control and Environmental Sustainability

COST is supported
y the EU Framework Programme

EUROPEAN SCIENCE FOUNDATION ESF provides the COST Office
through a European Commissio

Scientific context and objectives in the Action

- **Contribute to WG1 objectives**:

  Fabrication of TiO_2 and ZnO nanostructures such as nanowires, nanotubes and nanorods for all transducers to be implemented

  Doping of TiO_2 and ZnO nanostructures

  Characterization of metal oxide nanostructures

- **Contribute to WG2 objectives**:

  Design of sensor devices for Air Quality

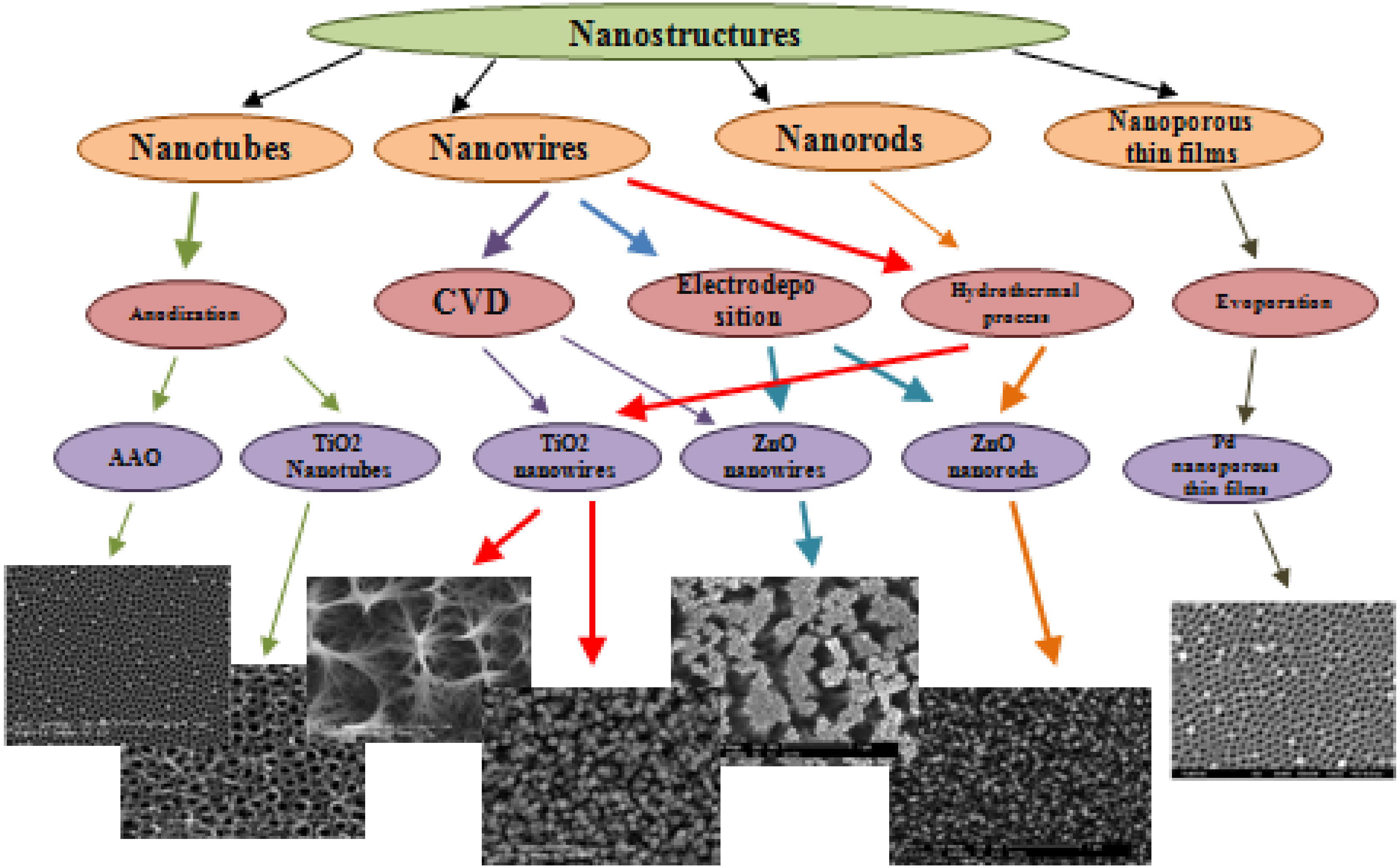
  Fabrication of sensor devices based TiO_2 and ZnO nanostructures for air pollutants such as CO, NO_2 and H_2

  Characterization of metal oxide nanostructures

  Characterization of sensor devices

  Fabrication of sensor arrays

Current research activities of GTU



Research Facilities available for GTU

FABRICATION

Anodization
- AAO Templates
- TiO_2 Nanotubes

Coating
- Sputtering
- Thermal Evaporation
- Spin Coating
- Sprey Coating
- Dip Coating

Hydrothermal
- TiO_2 Nanorods
- TiO_2 Nanowires
- ZnO Nanorods

CHARACTERIZATION

Structural
- AFM
- XRD
- SEM
- EDS

Electrical
- I-V
- C-V

GAS TEST
- H_2
- VOCs
- CO
- NO_2

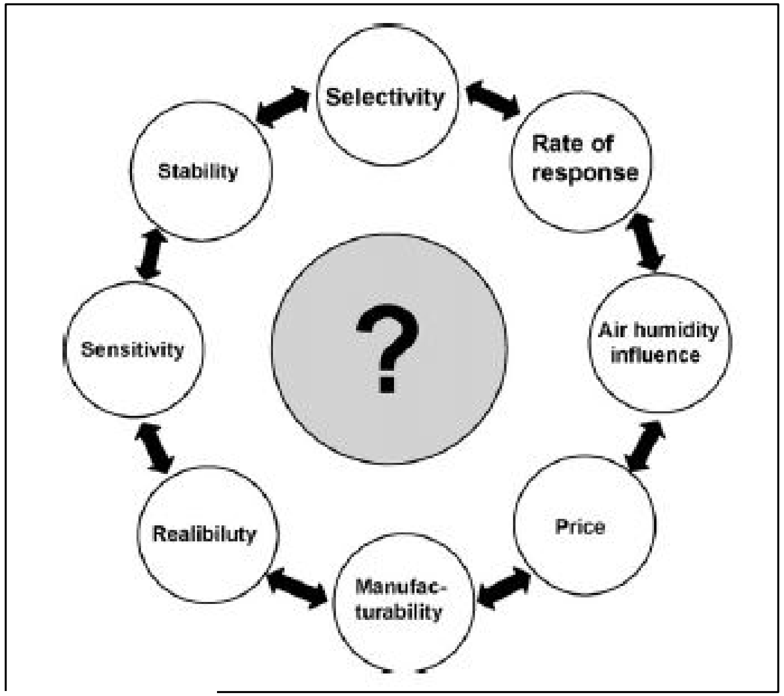
Suggested R&I Needs for future research

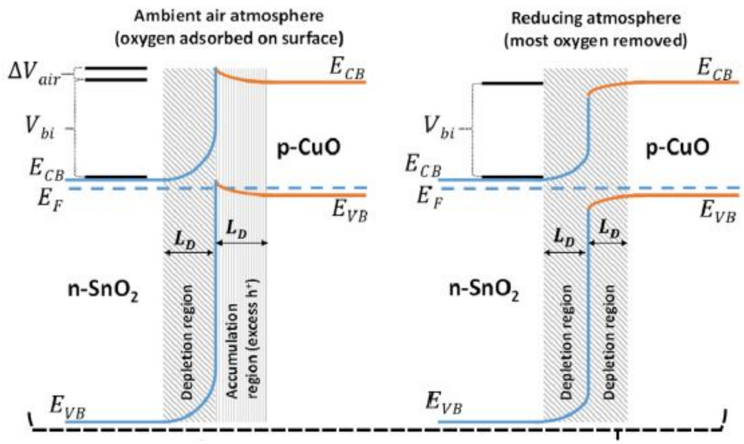
I. Metal-oxide gas sensor

II. Nanostructured MOS

III. Surface modification

IV. Heterostructures





G. Korotcenkov, 'The role of morphology and crystallographic structure of metal oxides in response of conductometric-type gas sensors', Materials Science and Engineering R, 2008.

Experimental

FABRICATION

I. Anodization
II. Thermal evaporation
III. Thermal oxidation

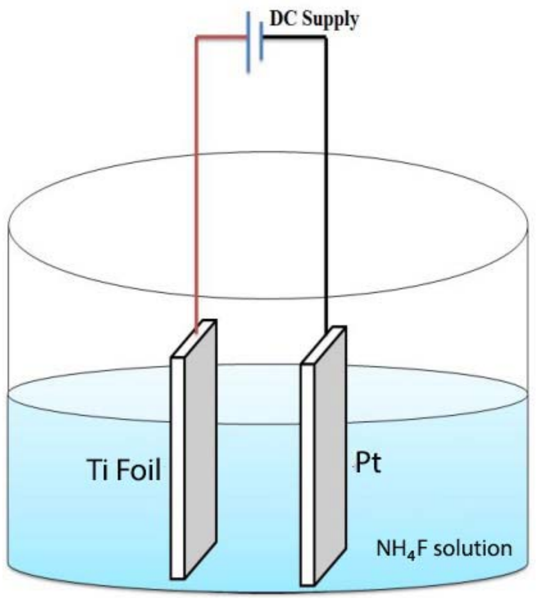
CHARACTERIZATION

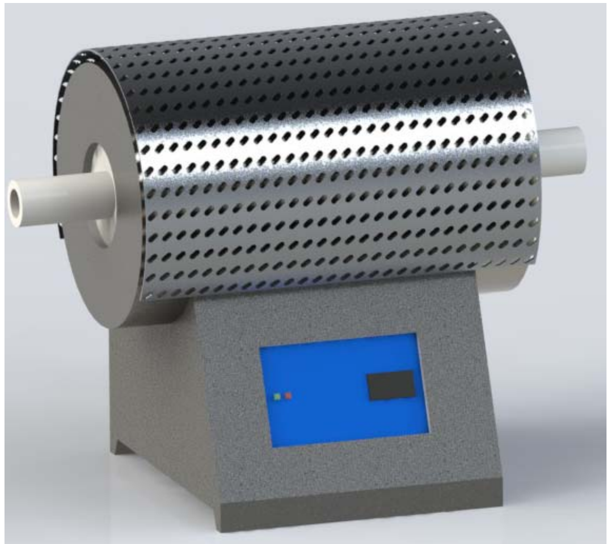
I. XRD
II. SEM
III. EDS

SENSOR MEASUREMENTS

I. H_2
II. VOCs
III. NO_2

Fabrication of TiO2 NTs

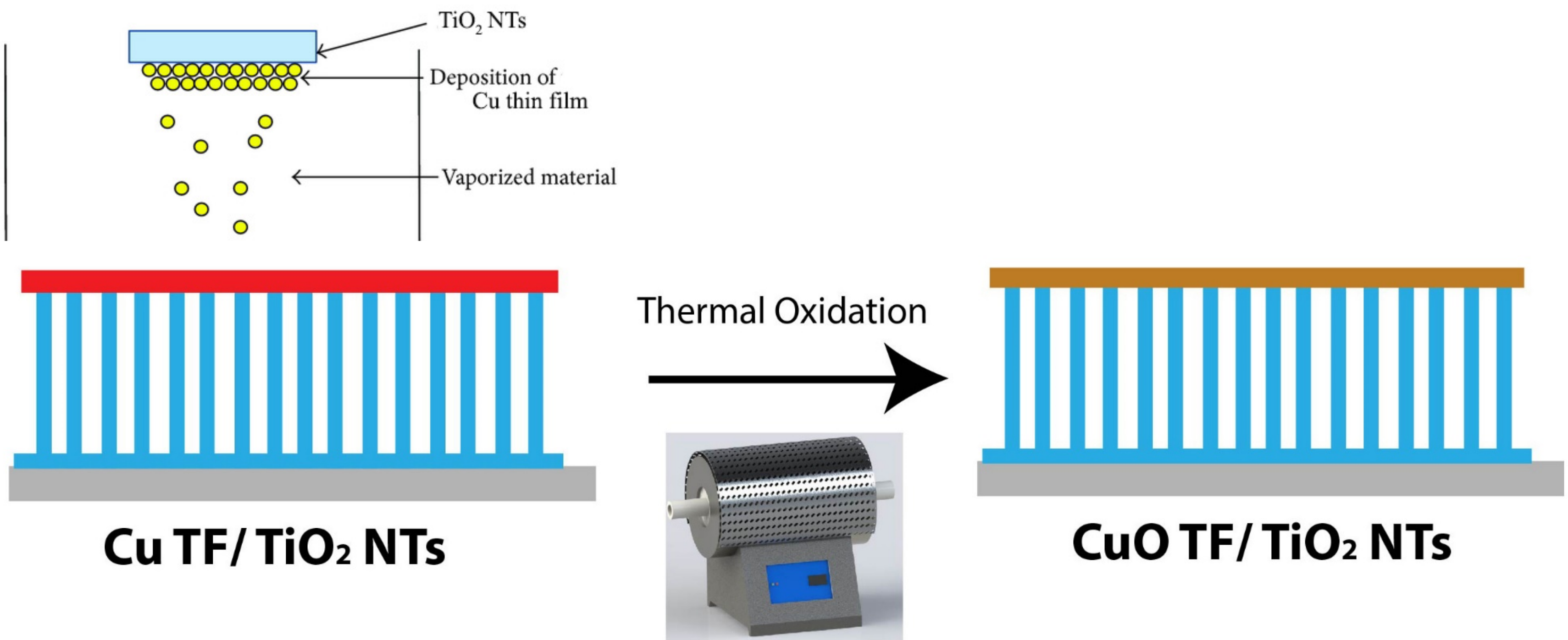




Anodization
Solution: % 0,25wt NH_4F in ethylene glycol
Process: 0º C, 50V, 60 min.

Annealing
In dry air
at 300˚ C
for 3 h.

Fabrication of CuO/TiO_2 NTs



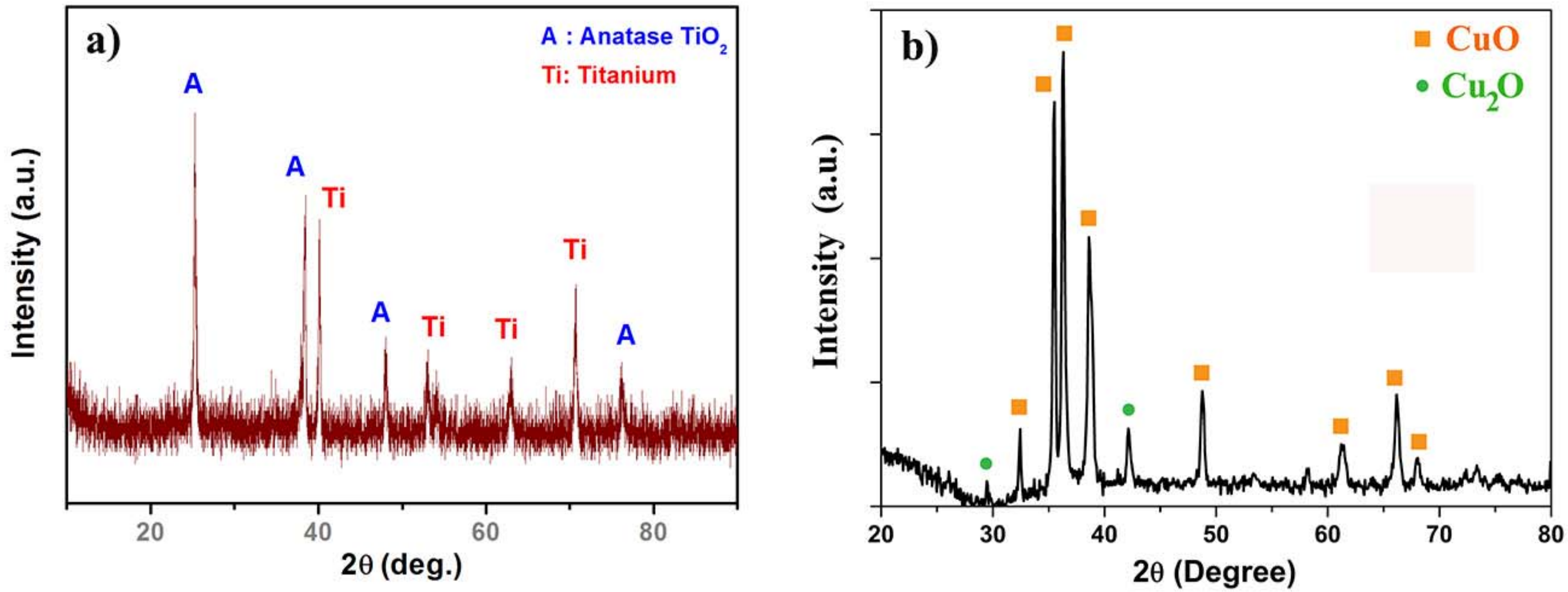
Thermal Evaporation;

- Leybold evaporation system
- 5 x 10^{-6} bar
- 100 nm Cu

Thermal Oxidation;

- In dry air
- 3 hour
- 400º C

Characterisation; XRD

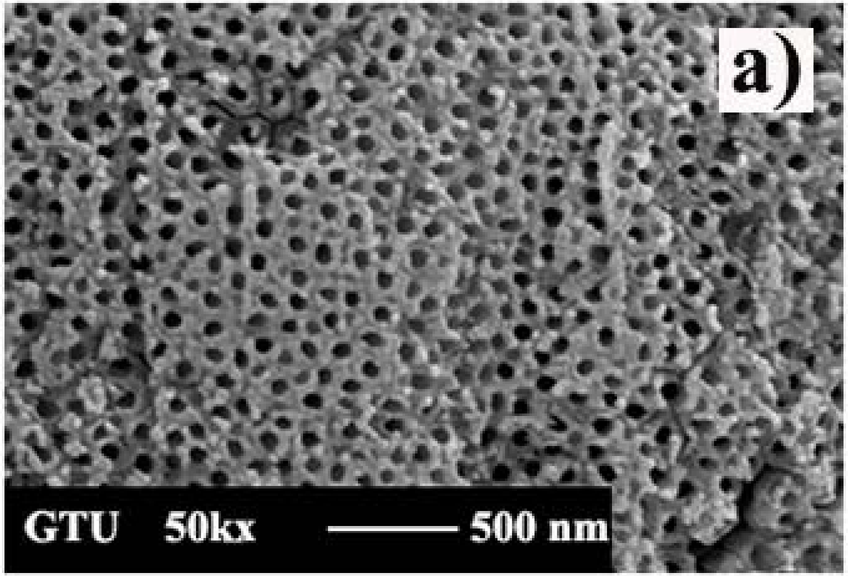


XRD pattern, GTU Rigaku Smartlab X-ray Diffraction

Sennik et al., J. All. Comp. 2014, 616, 89-96, Zhao et al., J. Mater. Chem. A, 2013,1, 367-

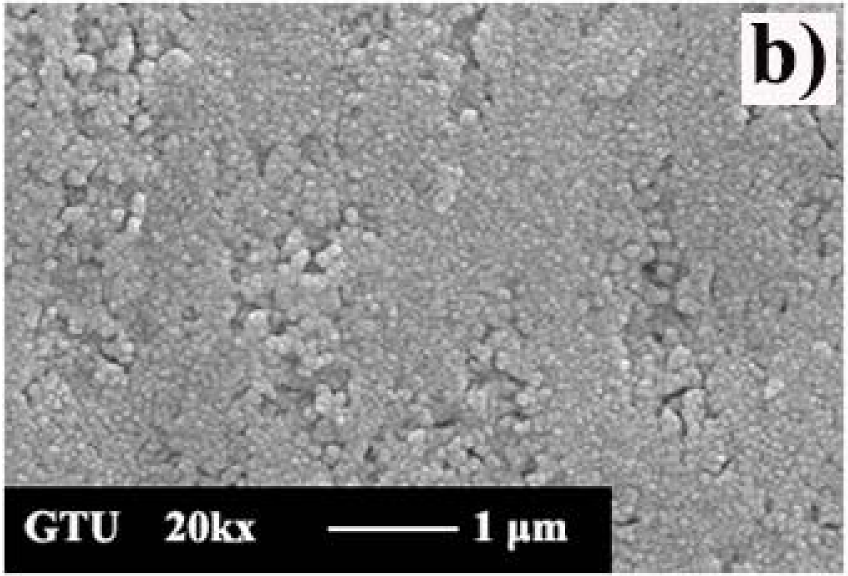
Characterisation; SEM

TiO_2 NTs



- ✓ 50 nm in diameter
- ✓ 1 µm in length
- ✓ Homogenously covered

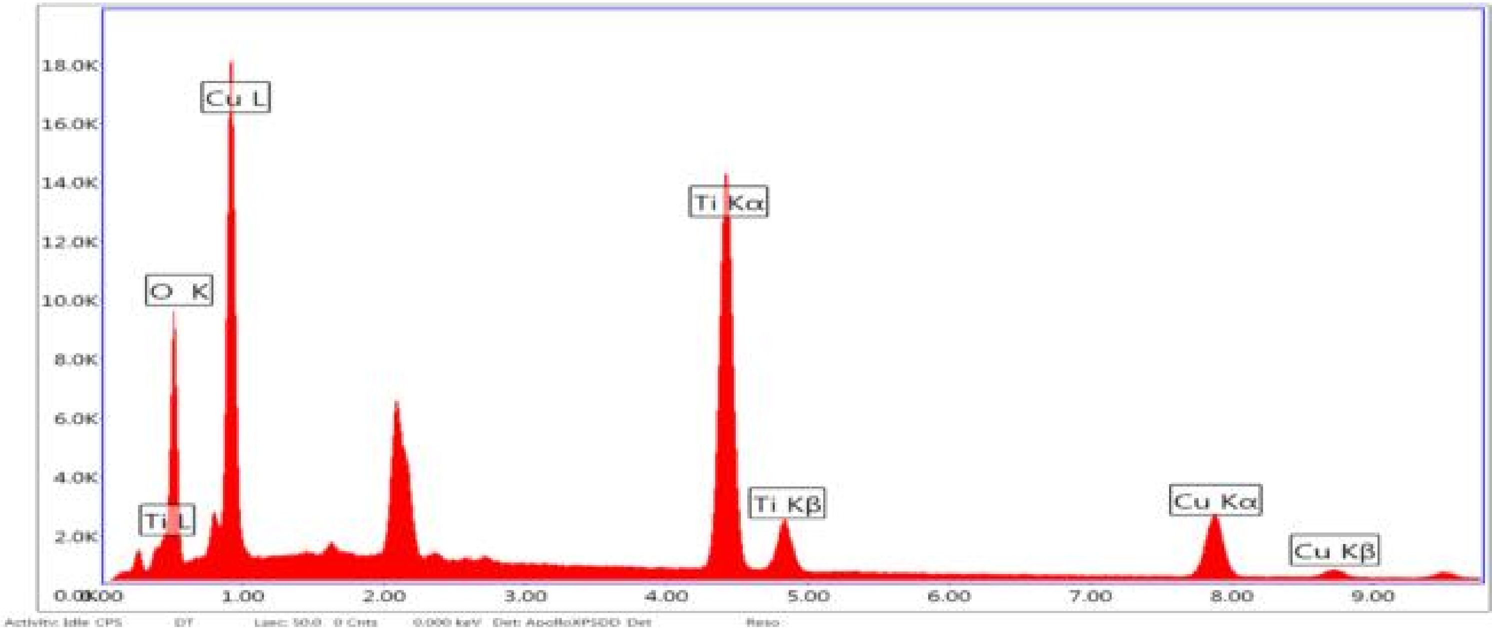
CuO TF/TiO_2 NTs



- ✓ Homogenously covered
- ✓ 100 nm thickness

SEM images, Gebze Technical University Philips XL 30 S

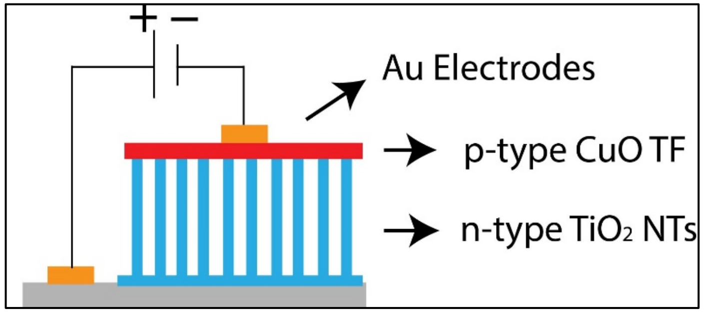
Characterisation; EDS



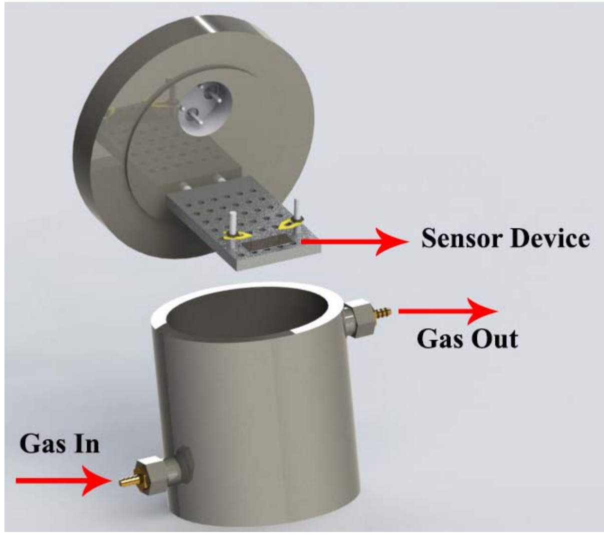
Element	Weight %	Atomic %
O K	27.44	54.41
Ti K	46.39	46.39
Cu K	26.16	26.16

EDAX Team EDS, Gebze Technical U.

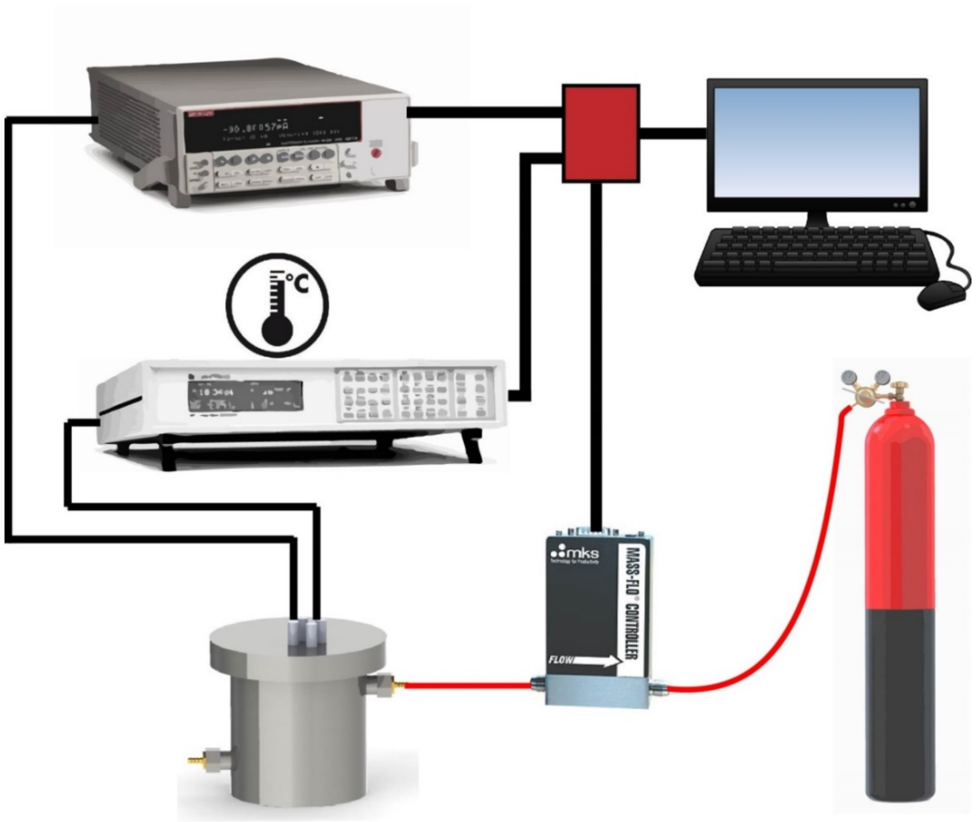
Sensor Measurement



Sensor Device

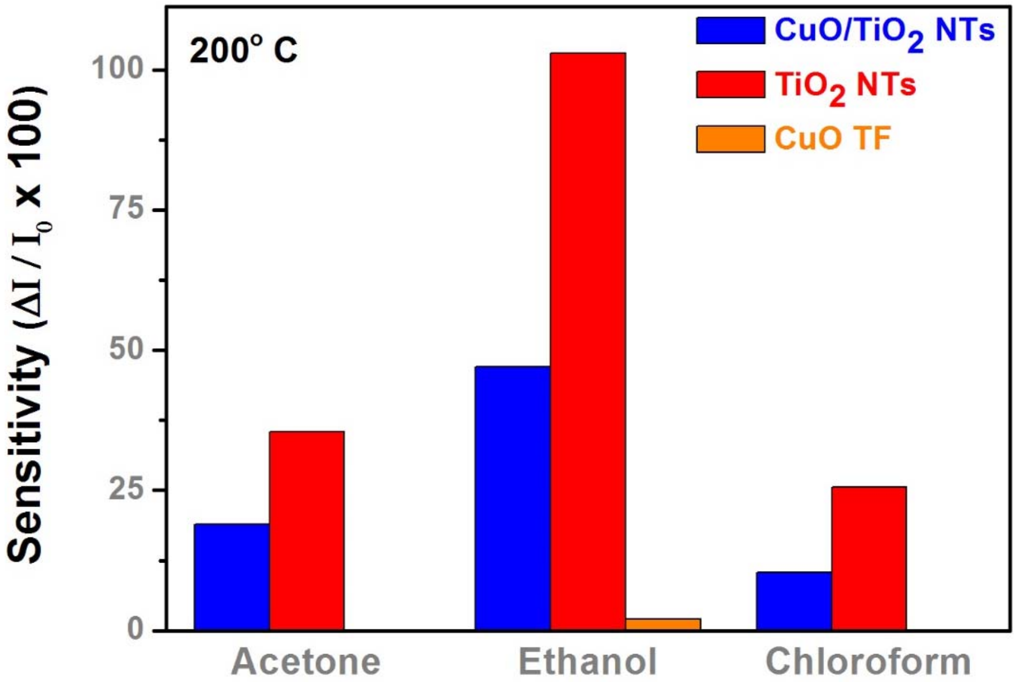


Gas Measurement Chamber



Gas Measurement System

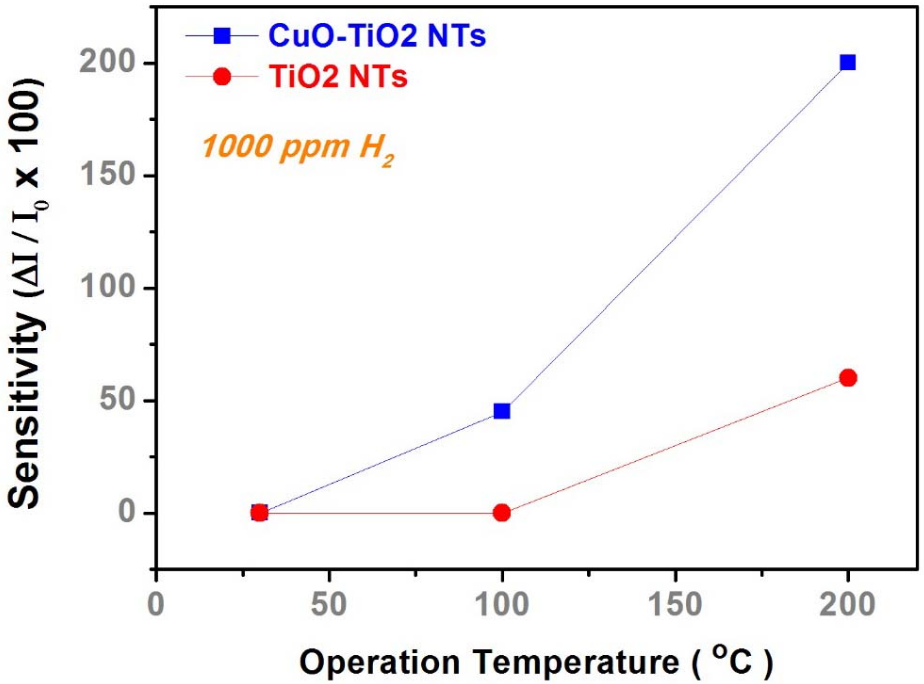
Sensor Measurement



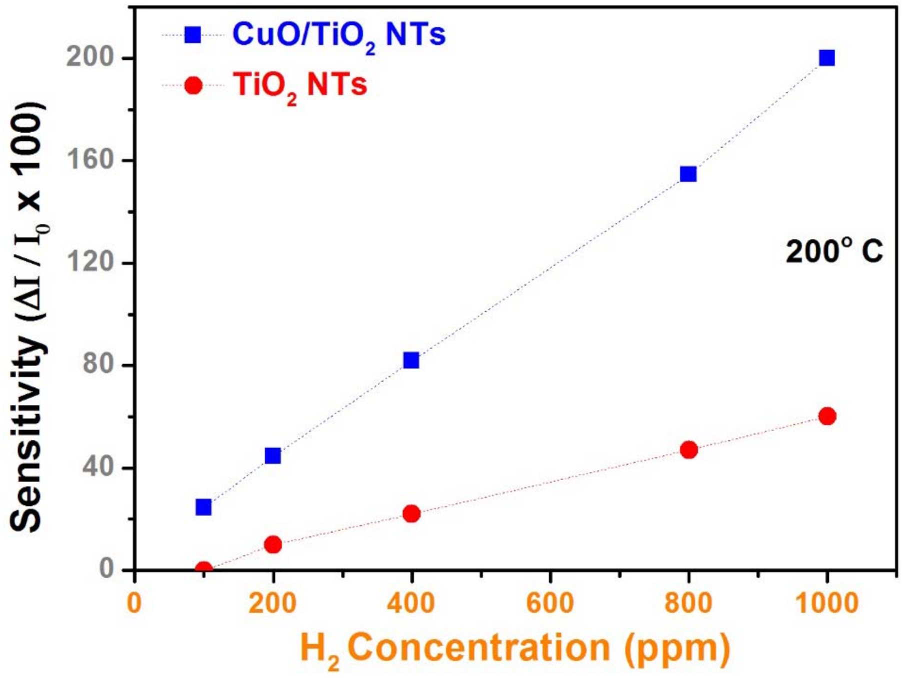
Sensitivity (%) against <u>5000 ppm VOCs</u> at 200˚ C.

- The heterostructure, TiO_2 NTs and CuO TF showed no response against VOCs below operation temperature of 200˚ C.
- CuO TF could only sense ethanol at 200˚ C.

Sensor Measurement

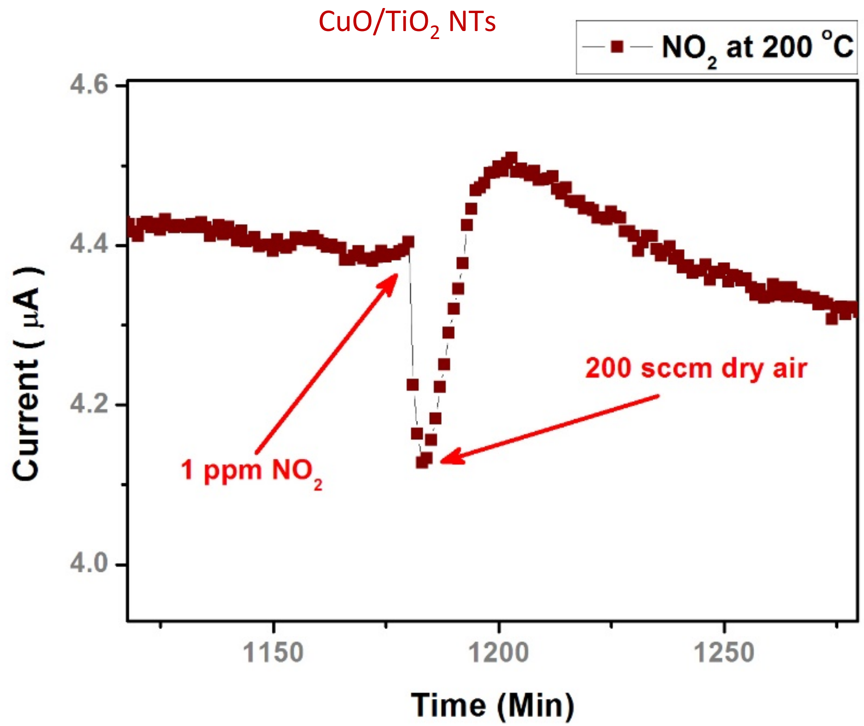


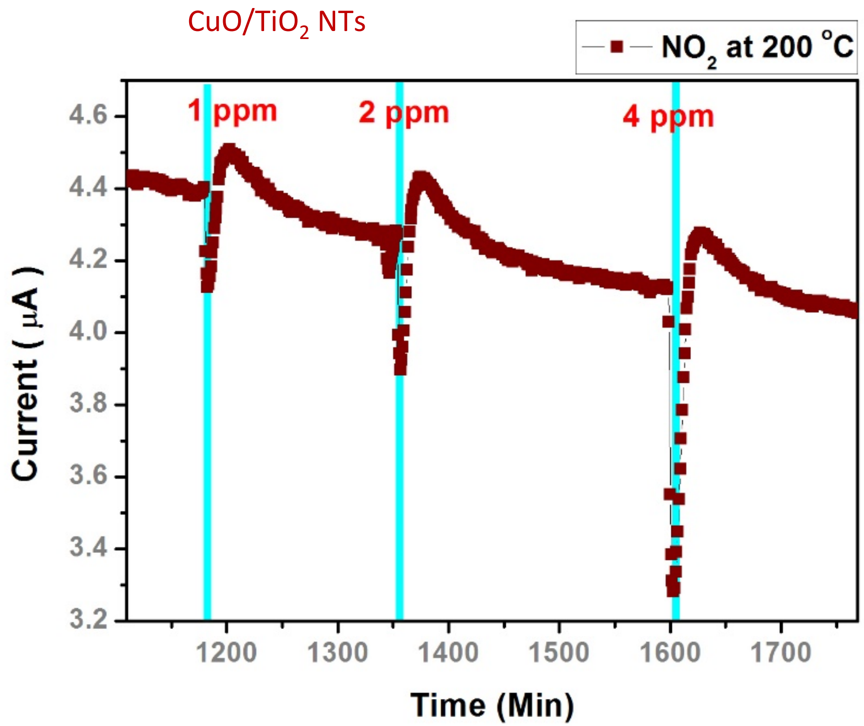
Sensitivity (%) dependent on operation temperature against 1000 ppm H_2



Sensitivity (%) dependent on H_2 concentration at operation temperature of 200˚ C

Sensor Measurement





- Though the heterostructure could detect NO_2, sensor response is very low compared to TiO_2 NTs.
- CuO TF showed no response against NO_2.

Conclusions

The heterostructure sensor has better sensitivity, lower detection limit and lower operation temperature against H_2 than the TiO_2 NTs sensor and CuO TF sensor.

Though the heterostructure sensor has clear response against NO_2 and VOCs (ethanol, acetone and chloroform) at operation temperature of 200˚ C, sensor responses are very low compared to TiO_2 sensor.

Selectivity the heterostructure formation not only increases the H_2 sensitivity but also decreases the VOCs and NO_2 sensitivity.

	H_2	VOCs	NO_2
The Heterostructure Sensitivity	↑	↓	↓

This means the heterostructure sensor is selective against H_2 among tested gas species.

ACKNOWLEDGEMENTS

Gebze Technical University;

- Sensor Laboratory
- Electron microscopy laboratory
- Center of Nanotechnology

The Scientific and Technological Research Council of Turkey(TUBITAK), project no ”113F403 ”.

COST

THANK YOU FOR ATTENTION!

cost
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