

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

COST Action TD1105

WGs & MC Meeting at SOFIA (BG), 16-18 December 2015

New Sensing Technologies for Indoor Air Quality Monitoring: Trends and Challenges

Action Start date: 01/07/2012 - Action End date: 30/04/2016 - Year 4: 1 July 2015 - 30 April 2016

GAS SENSORS BASED ON METAL OXIDE NANOSTRUCTURES FOR SENSING OF AIR POLLUTANTS

E. Şennik, O. Alev, O. Şişman, S. Öztürk, N. Kılınc, Z.Z. Öztürk¹

Zafer Ziya ÖZTÜRK

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

Gebze Technical University, Dept. of Physics,

41400 Kocaeli, TURKEY

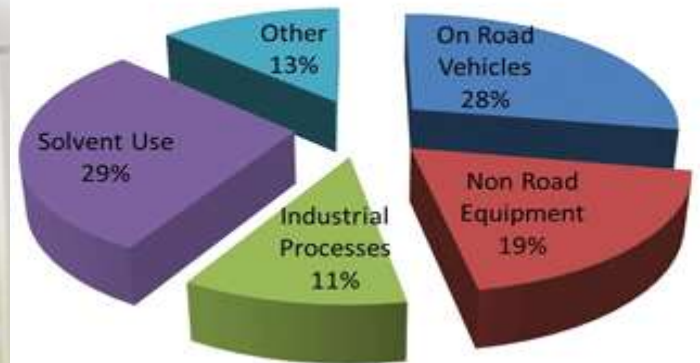




SOURCES OF INDOOR POLLUTANTS



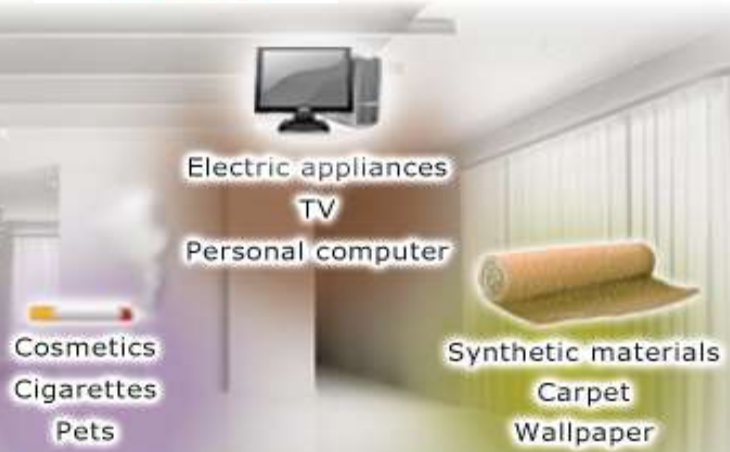
Sources of Volatile Organic Compounds



Source: epa.gov

VOCs

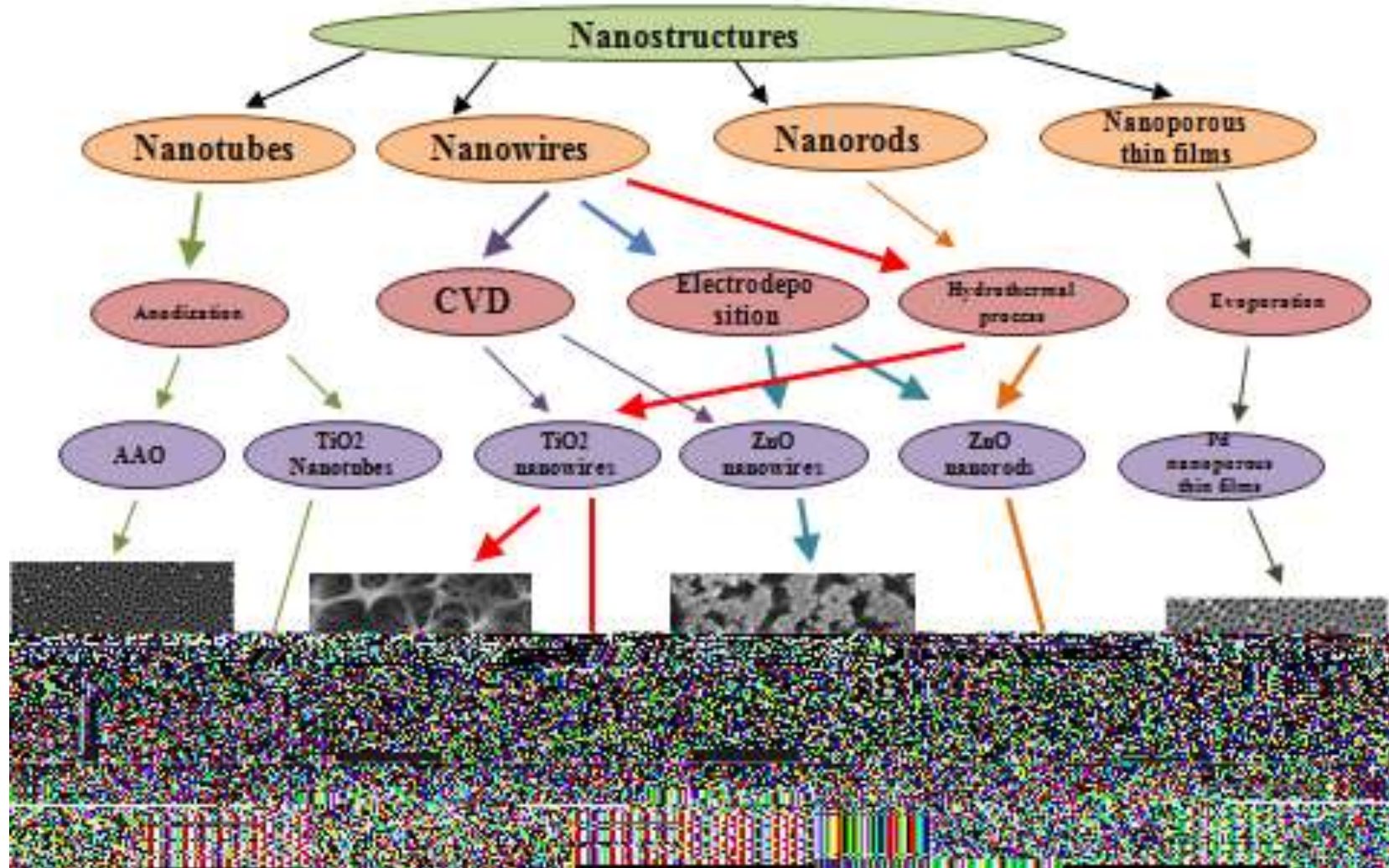
- Formaldehyde
- Toluene
- Xylene
- Benzene
- Ethylbenzene
- Trichloroethylene
- Styrene



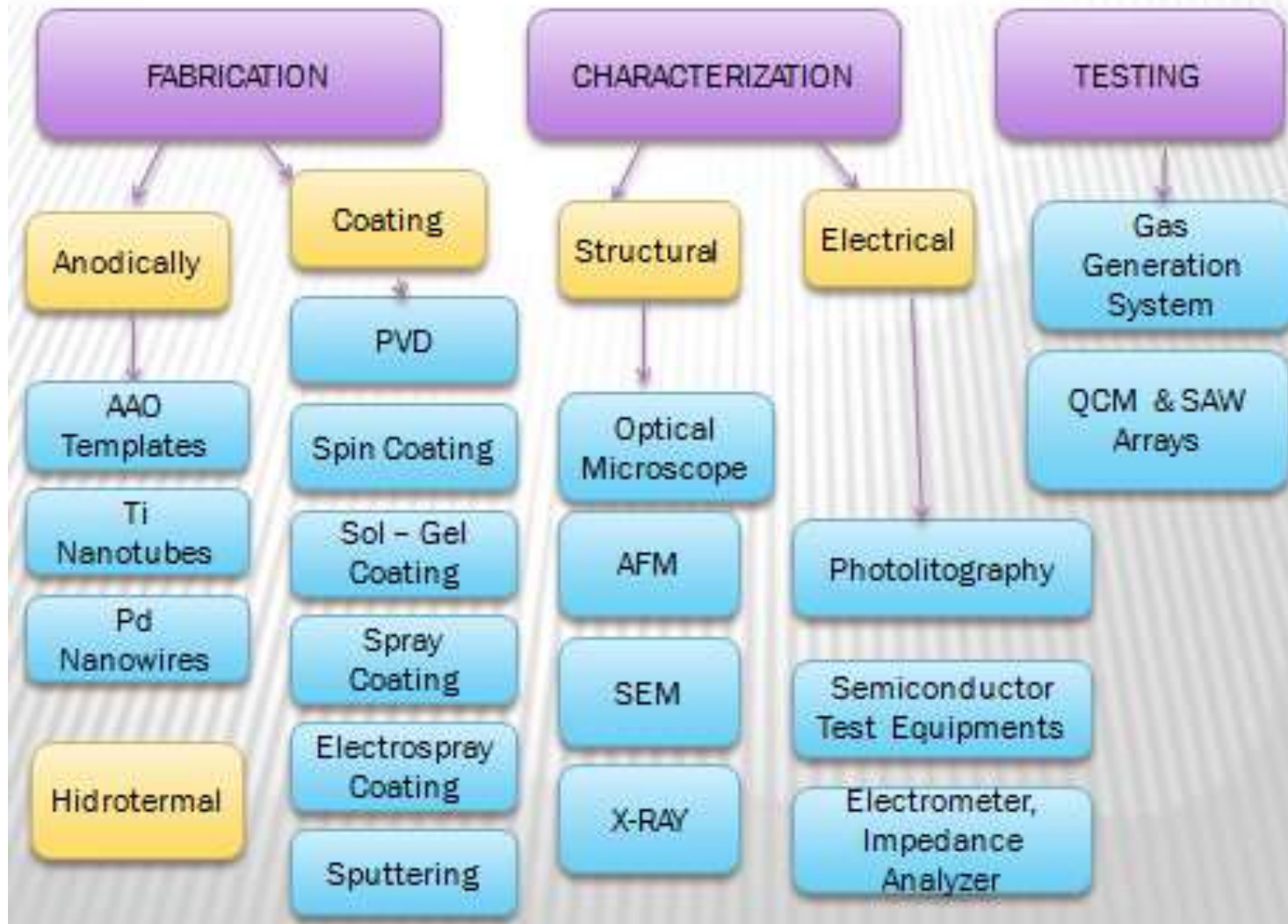
Scientific context and objectives in the Action

- The risky gases which may affect adversely air quality in the car are H_2 , CO , H_2S , NH_3 , NO_2 , CO_2 etc. According to USA EPA standards the limit values of the concentration for one hour exposure are 35 ppm (part per million) for CO , 100 ppb (part per billion) for NO_2 , 0,12 ppm for O_3 , 75 ppm for SO_2 , 10 ppm for H_2S etc.
- Within the frame of TD1105 EuAirNet, nanostructured doped-undoped metal-oxide semiconductor based gas sensors will be developed to control the air quality in car cabin including fuel cell battery operated vehicles.

Current research activities of Gebze Technical University



Research Facilities available for Gebze Technical University



Suggested R&I Needs for future research

- gas sensors based on doped/undoped nanostructured metal-oxide semiconductors will be developed for toxic gases such as H₂, CO, and NO₂.
- to fabricate inexpensive, sensitive and selective gas sensors for toxic gases in the car cabin from low level to high level concentrations with low power consumption,
- ZnO and TiO₂ nanostructures will be synthesized by using sol-gel, anodization, hydrothermal, chemical vapor deposition (CVD), and electrochemical methods.
- Fabricated sensor devices will be characterized against to gases H₂, CO, NO₂ and interference gases.

Fabrication of ZnO Nanowires

Anodic Aluminium Oxide Template

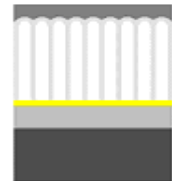
1. Fabrication of AAO



2. Coating of Au thin film on AAO surface



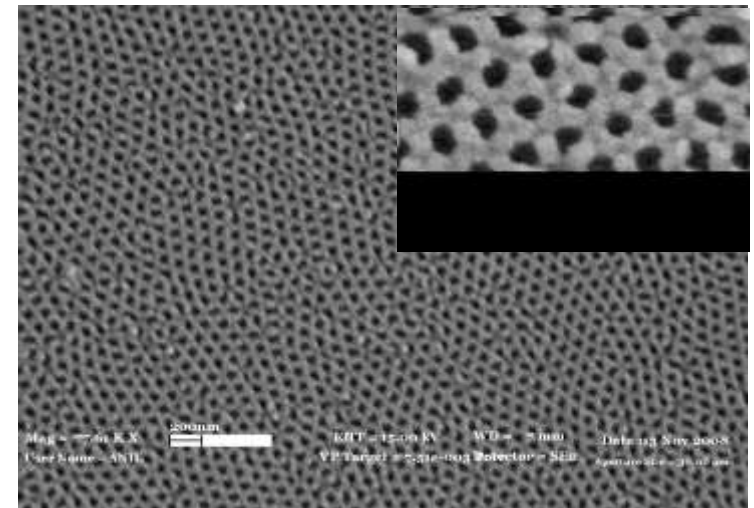
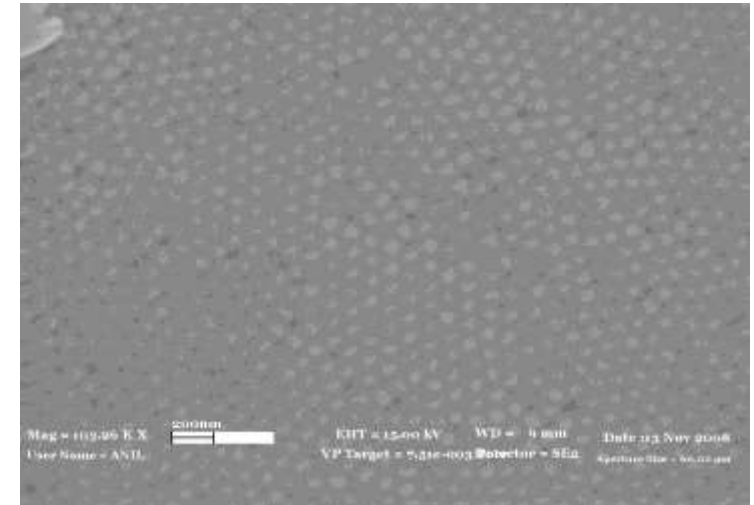
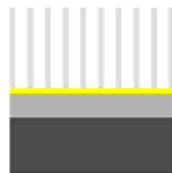
3. Attaching of Au coated AAO surface on Ti substrate with Ag paste



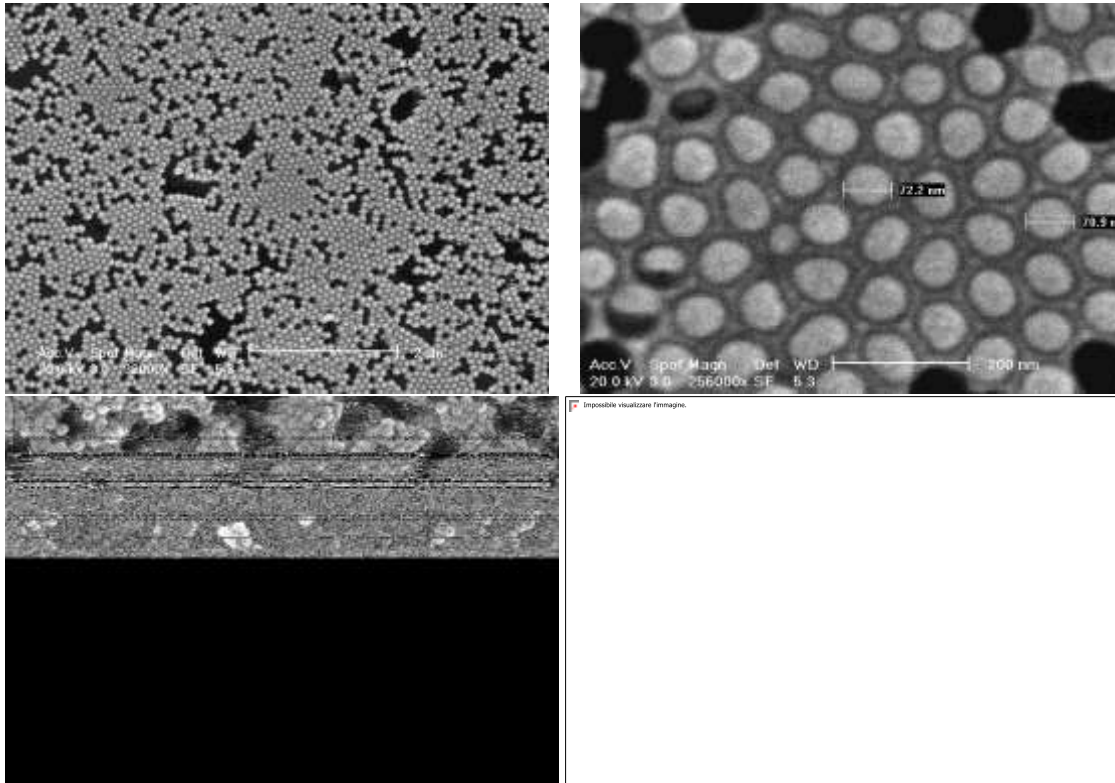
4. Etching of Al metal foil by HgCl₂



5. Removing of AAO barrier layer

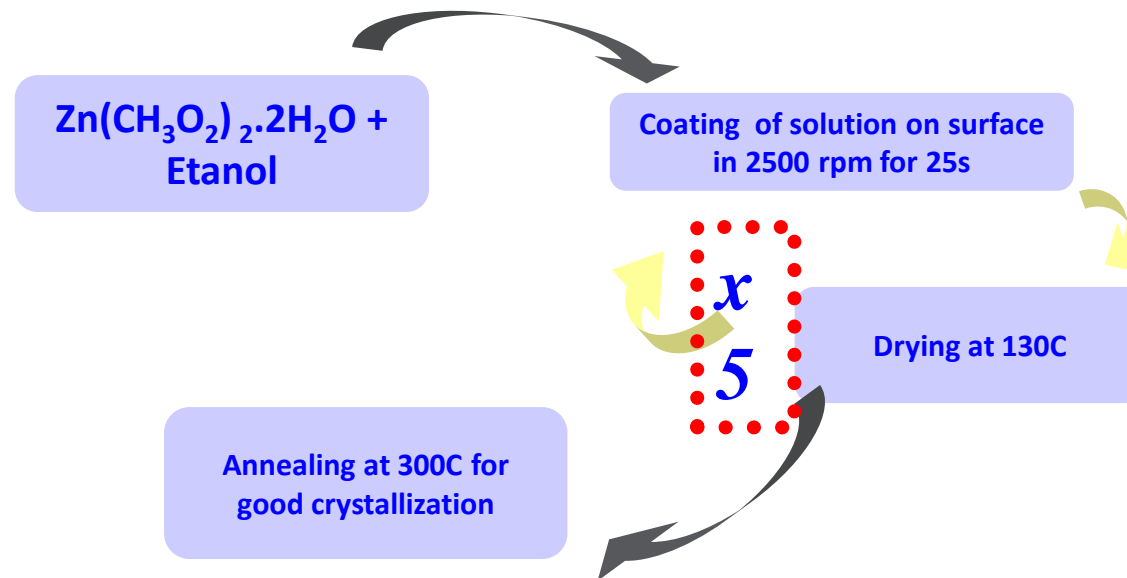


- *ZnO nanotellerin SEM görüntüsü*

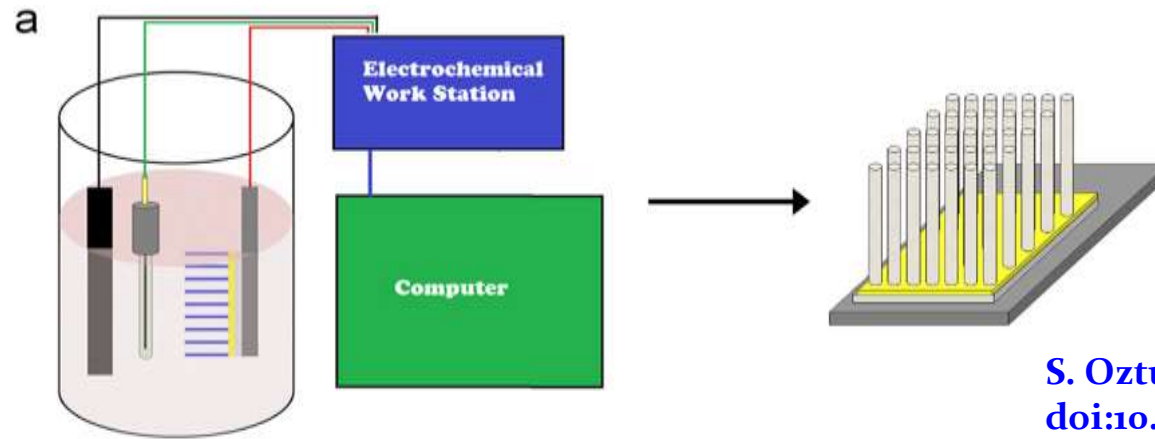


Fabrication ZnO nanorods

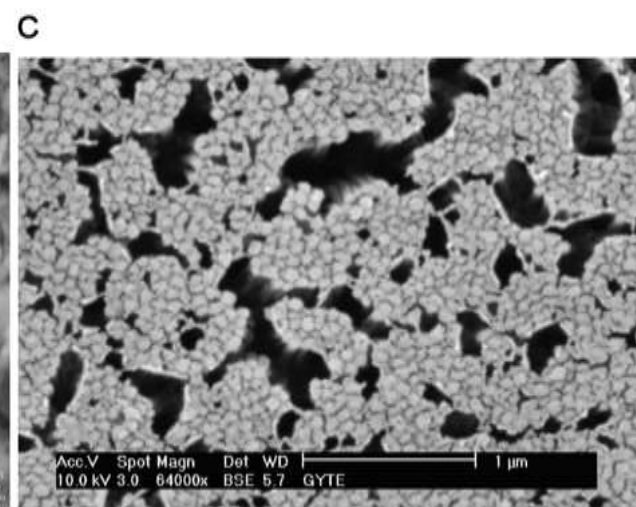
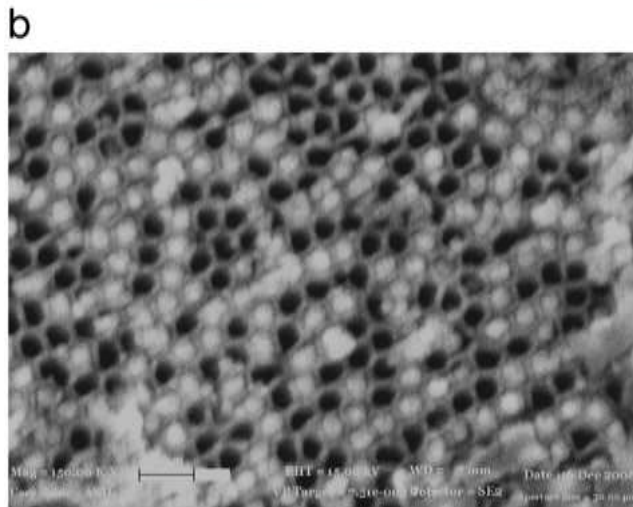
- Coating of ZnO thin film on glass by sol-gel process



Electrochemical Deposition



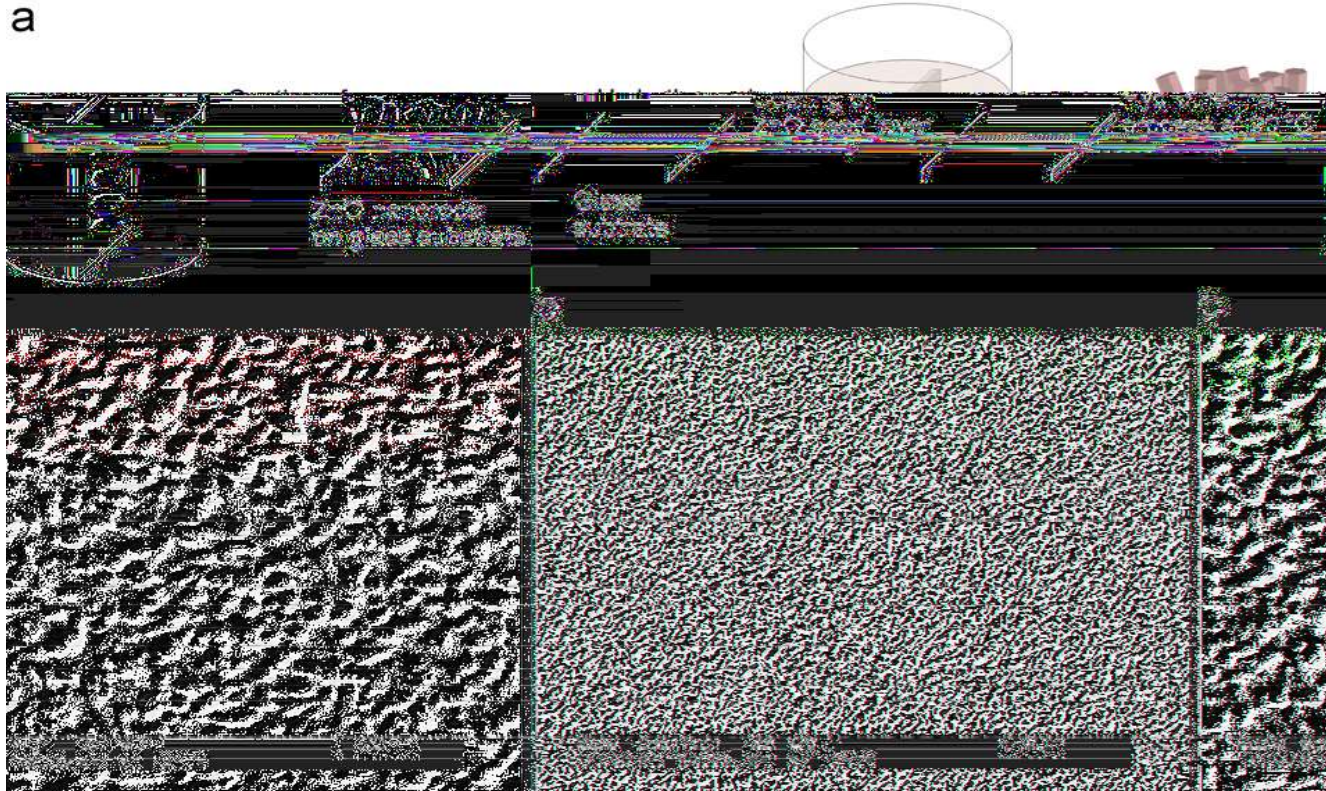
S. Ozturk, et al., Physica E (2011),
doi:10.1016/j.physe.2011.01.015



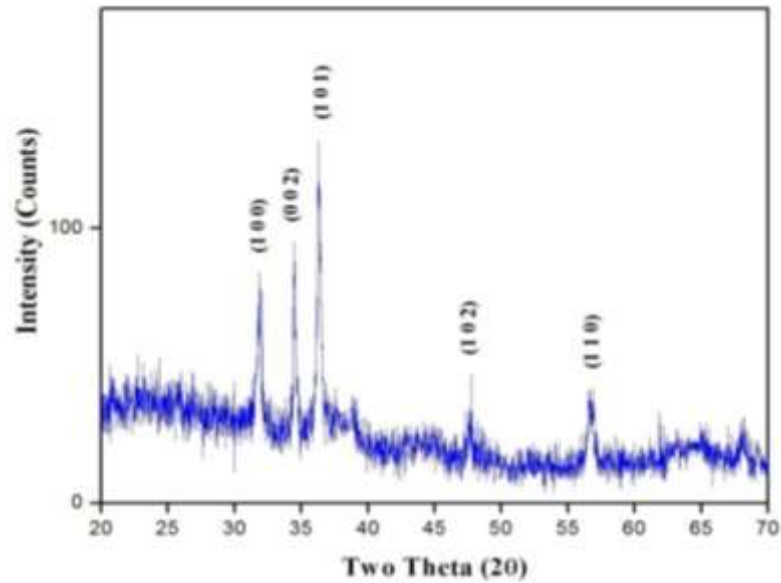
Hydrothermal fabrication of ZnO Nanorods

in equi molar ZnNitrate and Hexamethylenetetramines solution
at 90C for 3h in autoclavable glass beaker

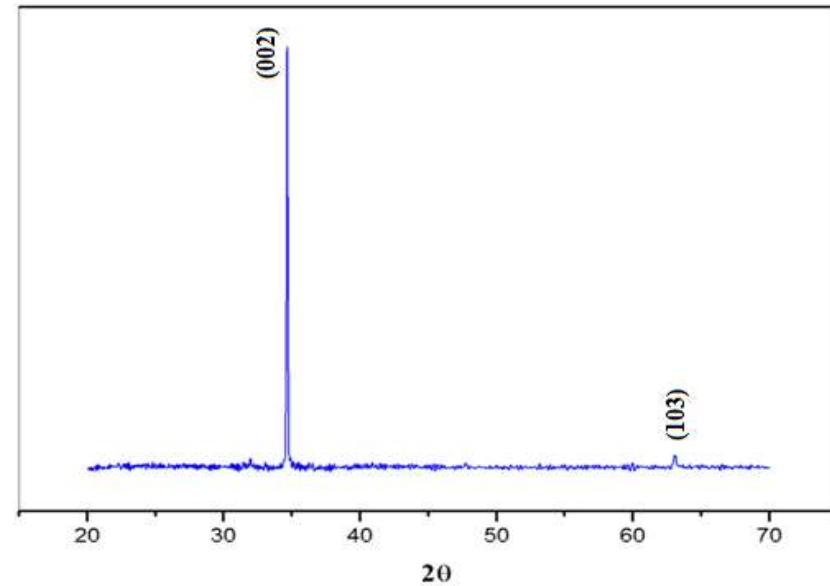
a



XRD results of ZnO nanostructures



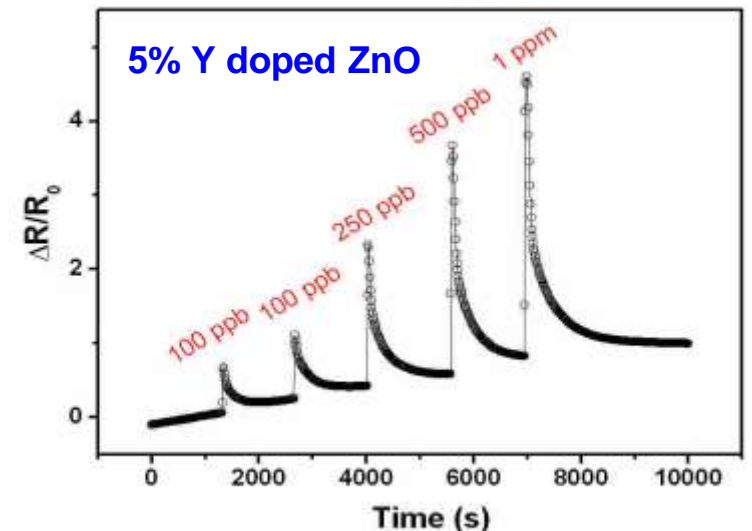
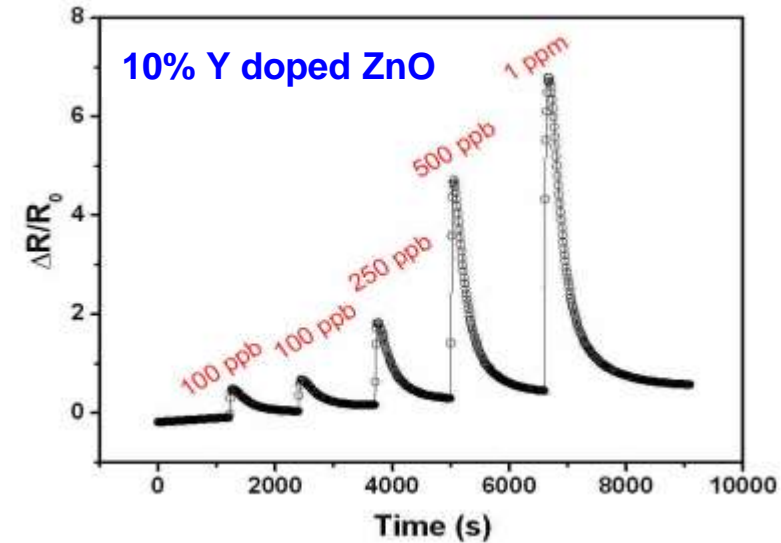
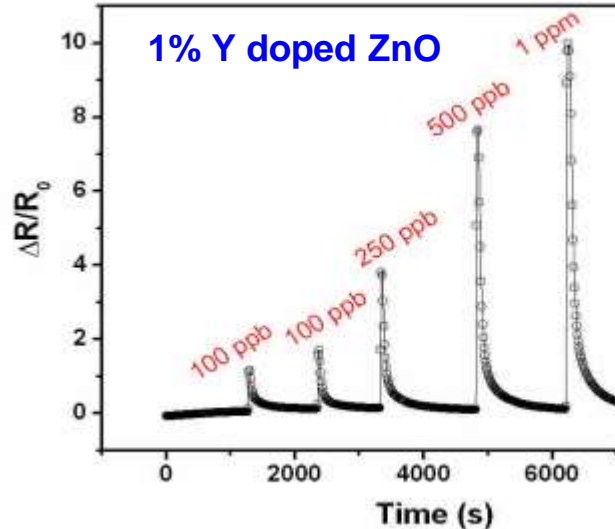
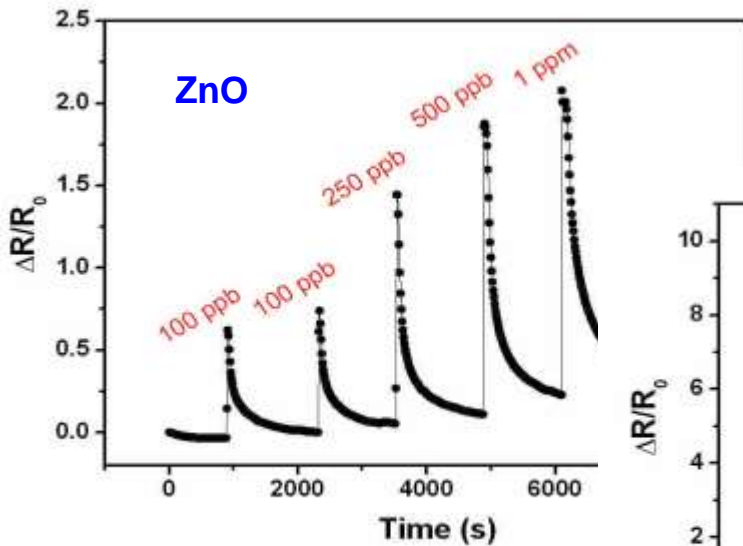
nanowires



nanorods

NO₂ Sensing Measurements

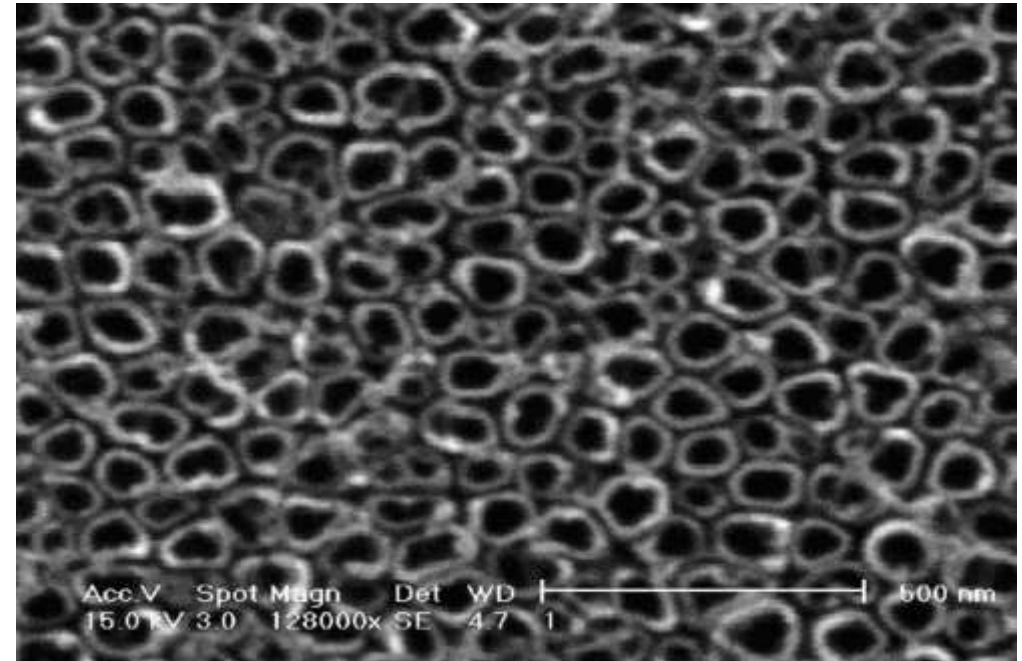
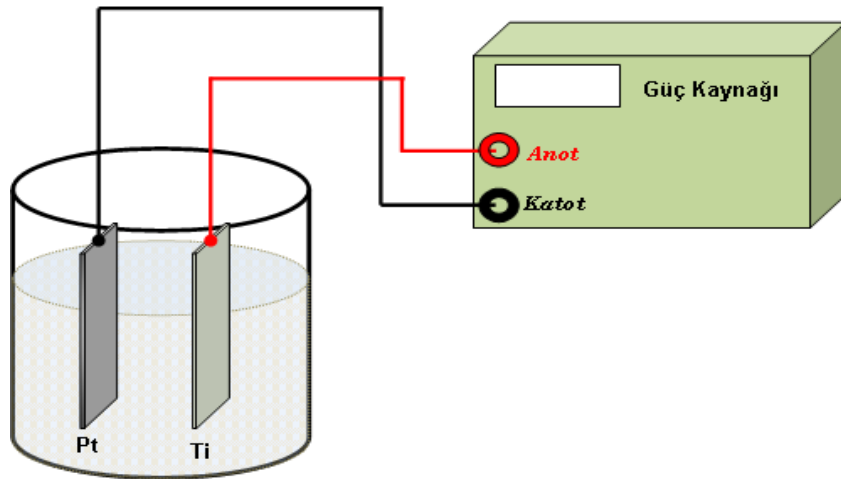
ZnO and Y doped ZnO thin films



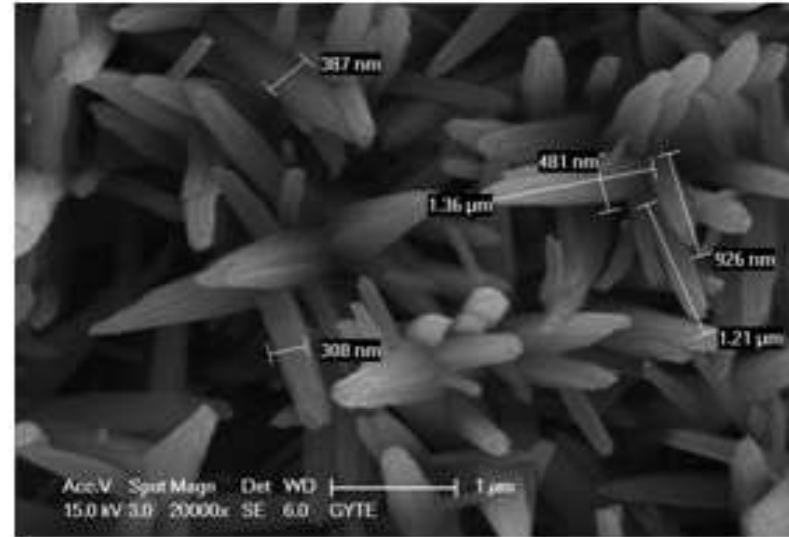
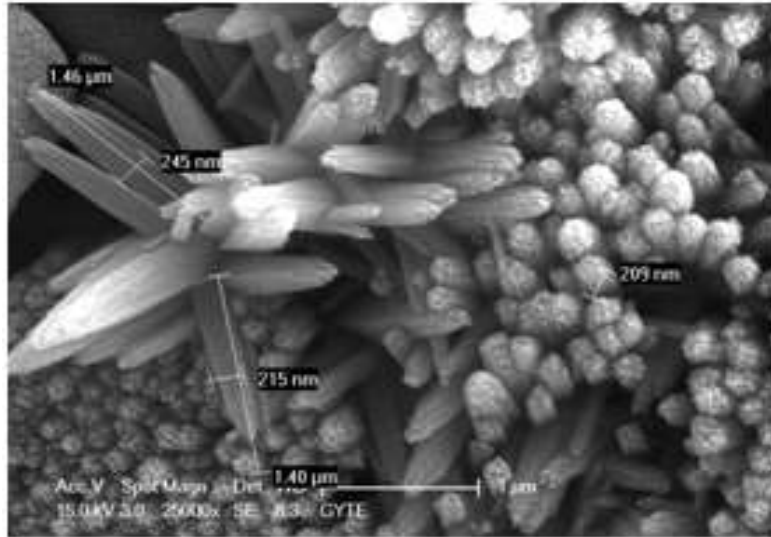
- Prior to gas sensing measurements, all samples are annealed at 600° C for 30 min, measurements carried out at 200°

Fabrication of TiO₂ Nanotubes

Anodic oxidation of Ti foil in aqueous HF solution
for fabrication TiO₂ nanotubes



Fabrication of TiO₂ Nanowires



VOC Sensing Properties of Hybrid Nanostructures

**Cleaning
of FTO
substrate**

**Hydrothermally
Fabrication of
TiO₂ nanorods
on FTO**

**Polymer
Coating on
TiO₂ nanorods
by spin coating**

**Sensor Device
Fabrication of
Heterostructures**

**Gas Test
Measurements**



Acetone (10 min.)
Isopropanol (10 min.)
Methanol (10 min.)



1 ml TnBT (HCl:Water)
150°C
18 h



Polymer P(S-co-CMS-
C₆₀) (P3) in chloroform
2000 rpm
60 sec.



Au contacts
150 nm

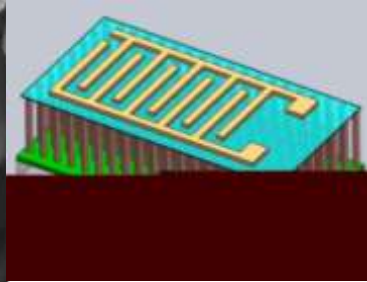
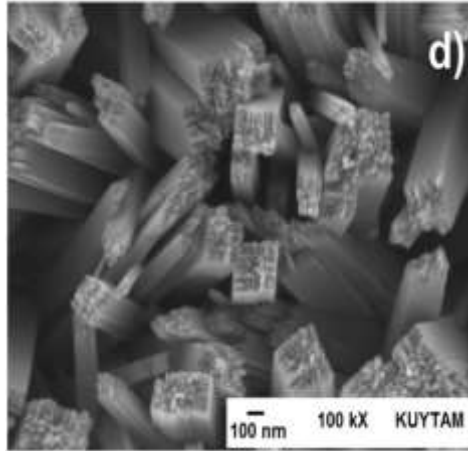
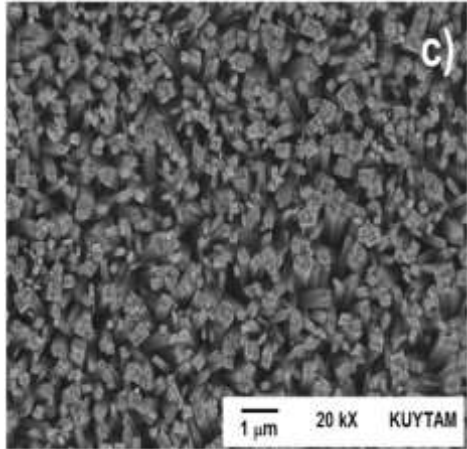
I-V
I-t

Working
Temperature

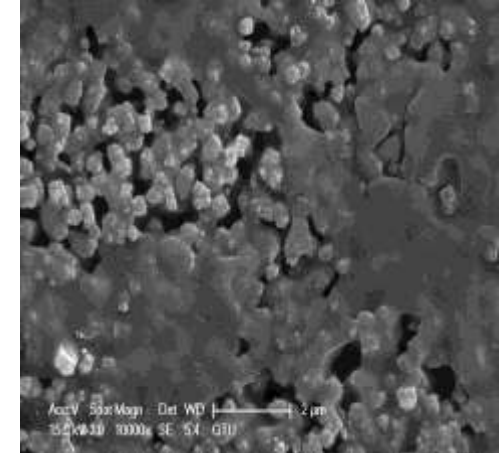
Different Gas
Concentration

VOC Sensing Properties of Hybrid Nanostructures

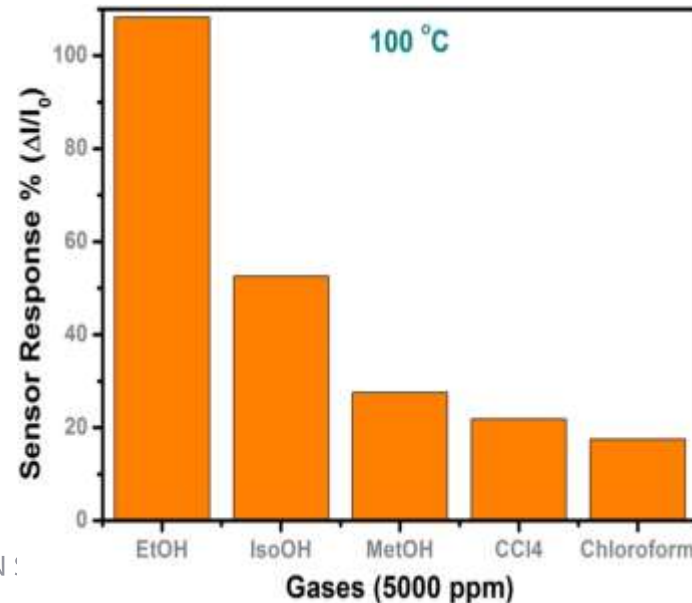
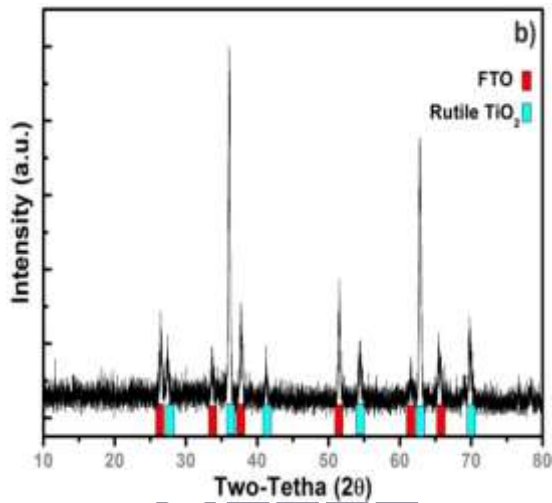
TiO₂ nanorods



Polymer/TiO₂ nanorods



VOC Sensing Properties of Heterostructures



H₂ Sensing Properties Heterostructure

