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

COST Action TD1105

WGs and MC Meeting at LINKOPING, 3 - 5 June 2015

Action Start date: 01/07/2012 - Action End date: 30/06/2016

Year 3: 1 July 2014 - 30 June 2015 (*Ongoing Action*)

VOC SENSING PROPERTIES OF HYBRID NANOSTRUCTURES

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Function in Action: MC Member, WG Member

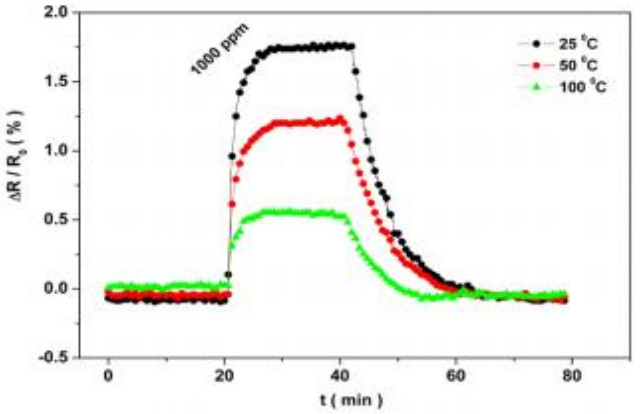
Kocaeli / Turkey

COST is supported by the EU Framework Programme

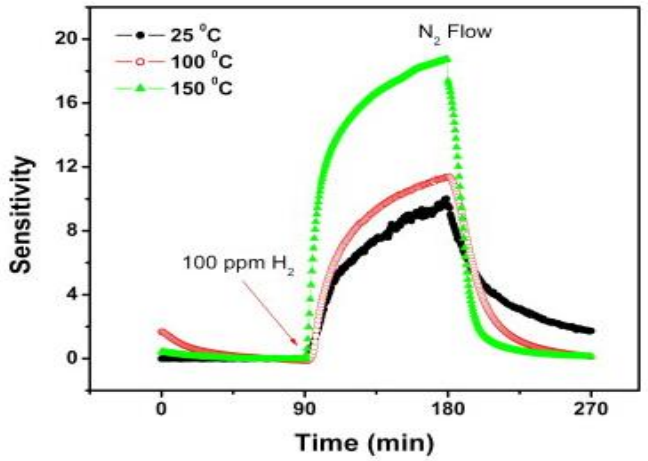
ESF provides the COST Office through a European Commission contract

Main Research Area

- **Sensitive Materials**
  * Metal oxide nanowire, nanotube and nanorod fabrication
  * Metal nanowire fabrication
  * Preparation of metal oxide and organic (phthalocyanines, porphyrins and oximes) thin films
- **Transducers**
  * IDT, MIS, MS
  * QCM
  * SAW
- **Sensor array, Pattern recognition**
- **Development of chemical and biochemical sensors**



H_2 response of nanoporous Pd thin film



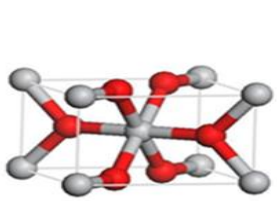
H_2 response of TiO2 nanotubes

Purpose

- Fabrication of functional heterostructures.
- Promoting of sensing properties of metal oxides
  - Decreasing working temperature.
  - Increasing sensitivity.

Properties of TiO_2 and Polystyrene Polymer

- **TiO_2**



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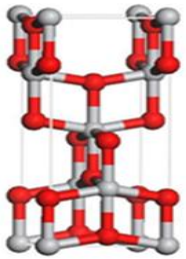

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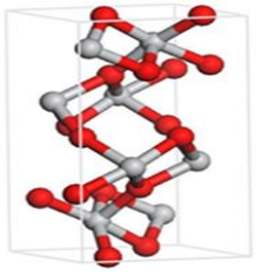
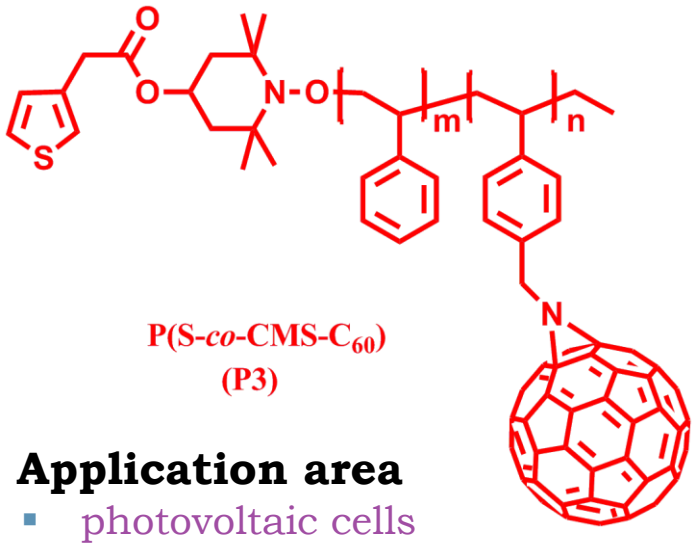


Brokit

- **Application area**
  - nano/microelectronics
  - sensors, transducers
  - optoelectronic
  - Industry

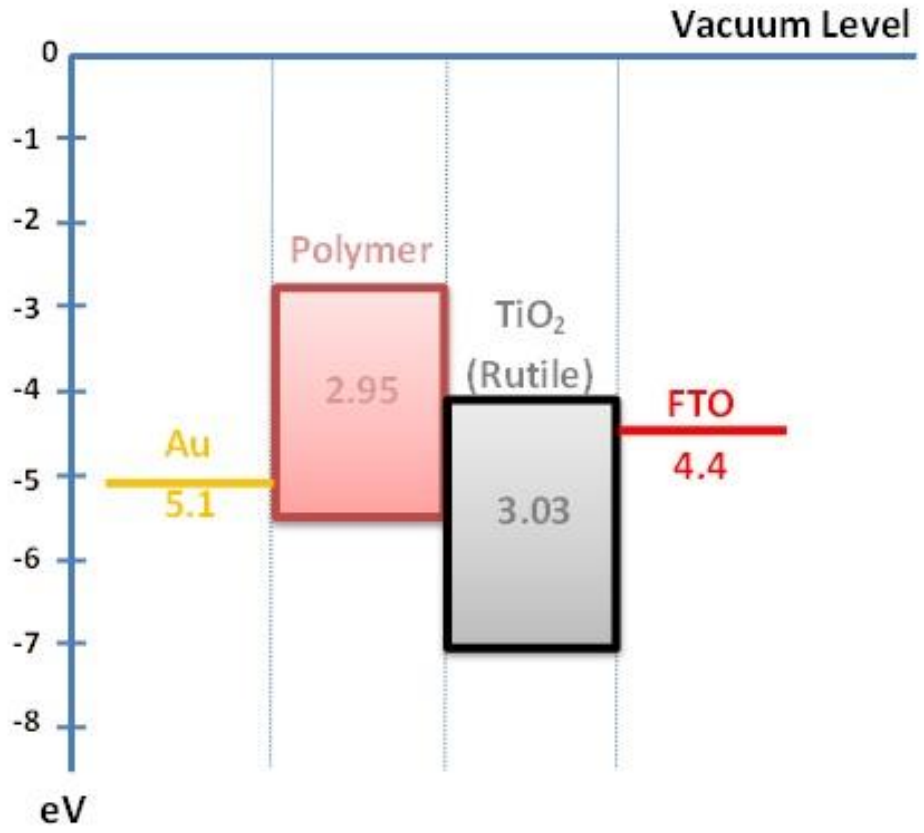
- **Polystyrene Polymer**



P(S-*co*-CMS-C_{60})
(P3)

- **Application area**
  - photovoltaic cells
  - electroluminescent devices
  - optical limiting
  - photoinduced electron transfer

Estimated Band Diagram



Fabrication Processes of Heterostructure Gas Sensor

Cleaning of FTO substrate

Hydrothermally Fabrication of TiO_2 nanorods on FTO

Polymer Coating on TiO_2 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 in chloroform
2000 rpm
60 sec.

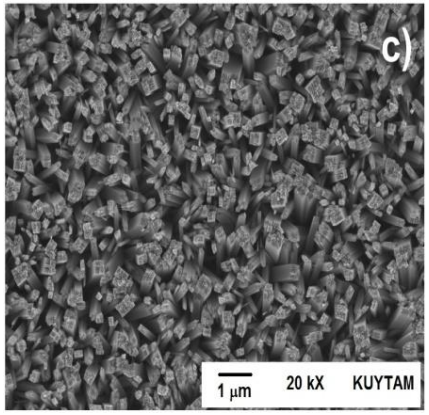
Au contacts
150 nm

I-V
I-t

Working Temperature

Different Gas Concentration

Fabrication of TiO_2 nanorods



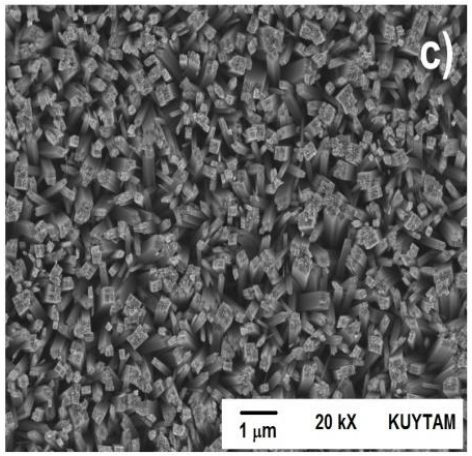
- TiO_2 nanorods were hydrothermally fabricated onto fluorine-doped tin oxide (FTO) substrate. 1 ml Titanium (IV) n – butoxide was used as a Ti precursor and mixed by HCl: deionized water with equal volume. The hydrothermal reaction was performed in teflon lined stainless steel autoclave at 150 °C for 18 h. Fig. a shows schematic illustration about teflon and stainless steel autoclave which used for growth nanorods on FTO by hydrothermal method. SEM image of TiO_2 nanorods is given by Fig. b.

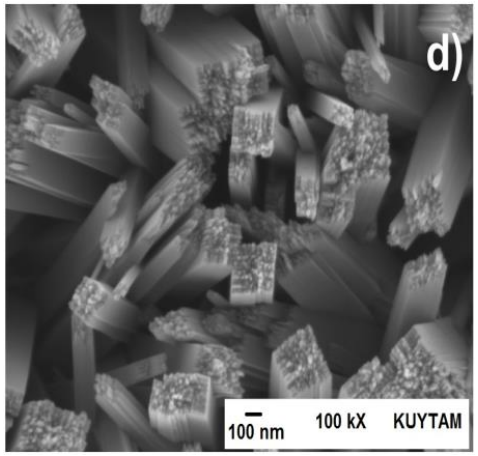
P(S-*co*-CMS-C_{60}) (P3) Synthesis

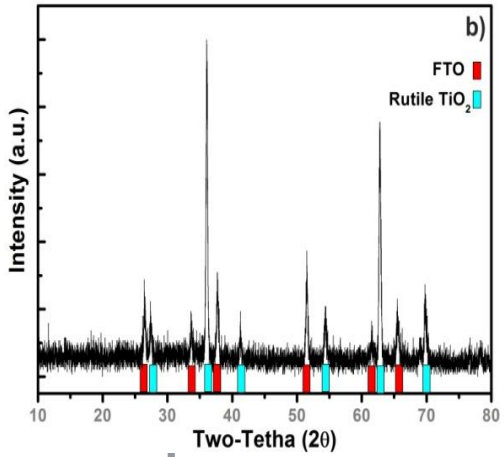
- P(S-*co*-CMS-C_{60}) (P3) was prepared as follows: A mixture of P(S-*co*-CMS-N3) (P2), C_{60} and chlorobenzene was placed in a round bottom flask and degassed by bubbling argon for 10 min. The homogeneous reaction mixture was stirred at 60 ^{o}C under argon for 2d. The solution was heated 130 ^{o}C and allowed to continue overnight again. The resulting mixture was evaporated to dryness and then THF was added the residue. The mixture was stirred at room temperature. Unreacted C_{60} and other insoluble matters were filtered off. The clean filtrate was evaporated and dried in vacuum desiccator to obtain brown product. Then synthesized polystyrene polymer was coated on TiO_2 nanorods by spin coating method.

Structural Analysis of Hybrid Nanostructres

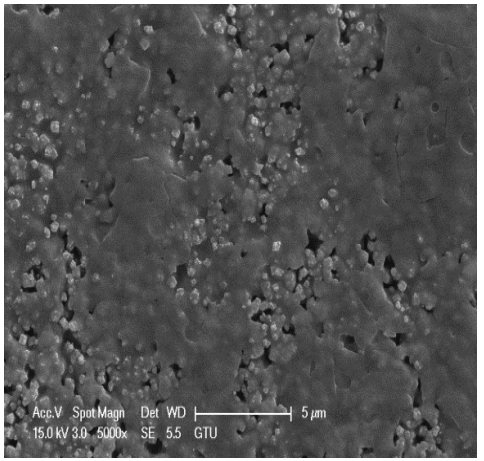
TiO_2 nanorods

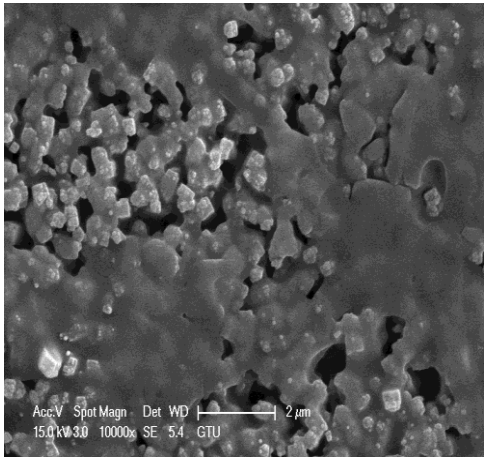




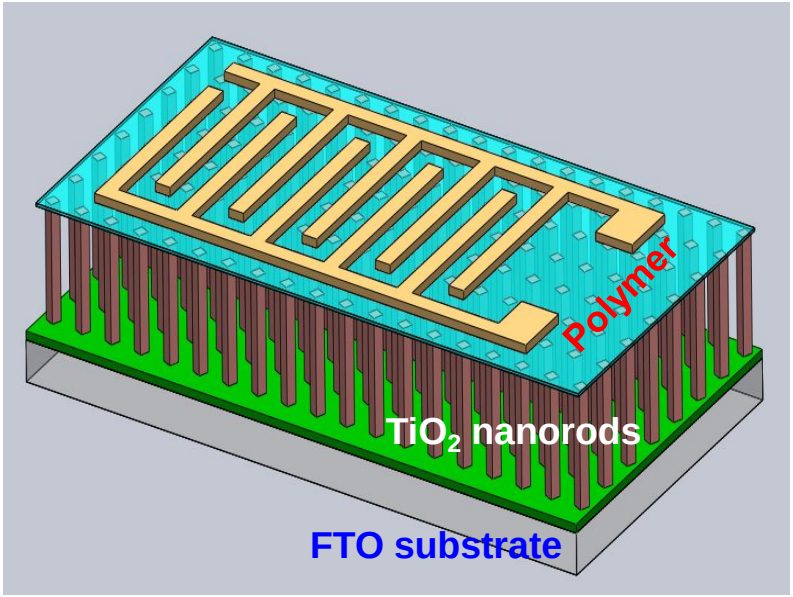


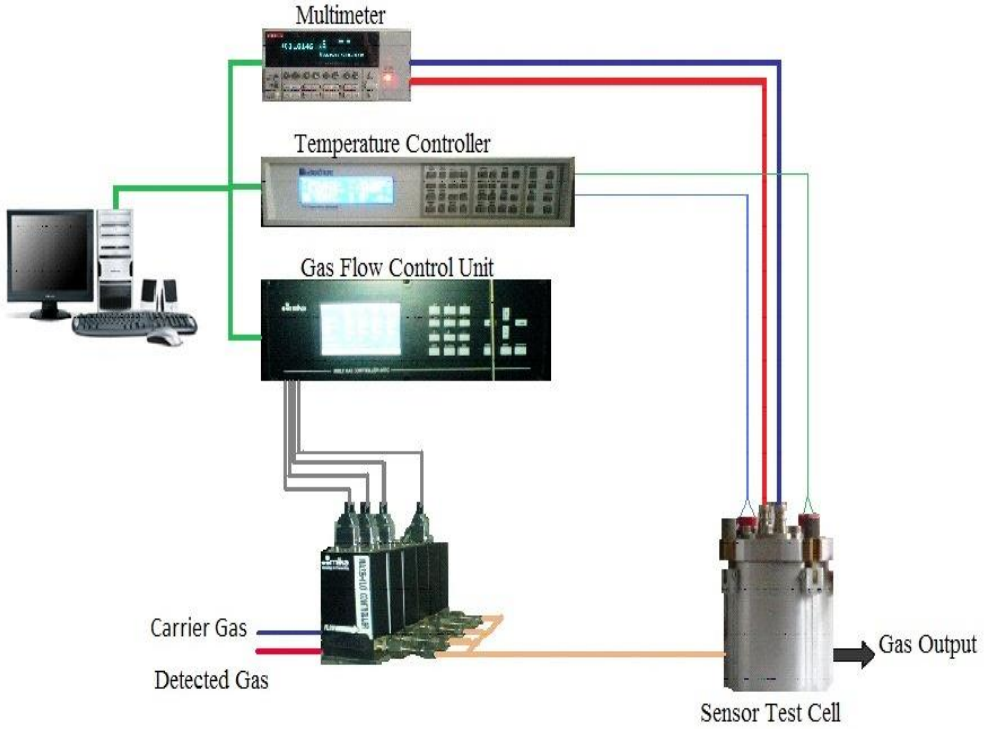
Polymer/TiO_2 nanorods





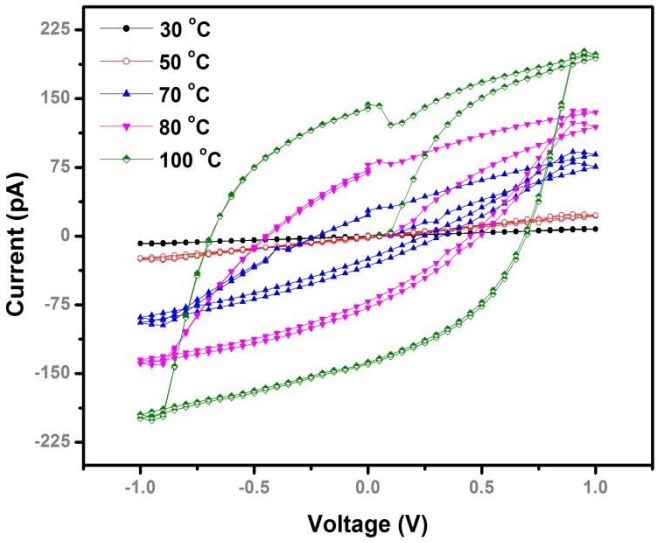
Sensor Device and Gas Test System



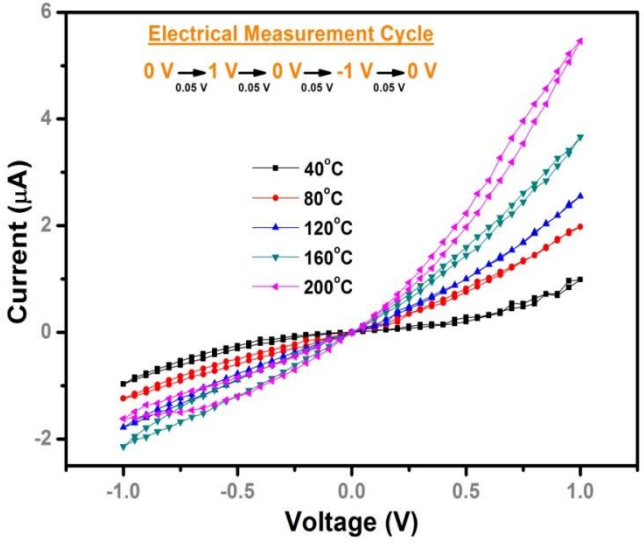


I-V characteristics of Polymer, TiO2 nanorods and heterostructure

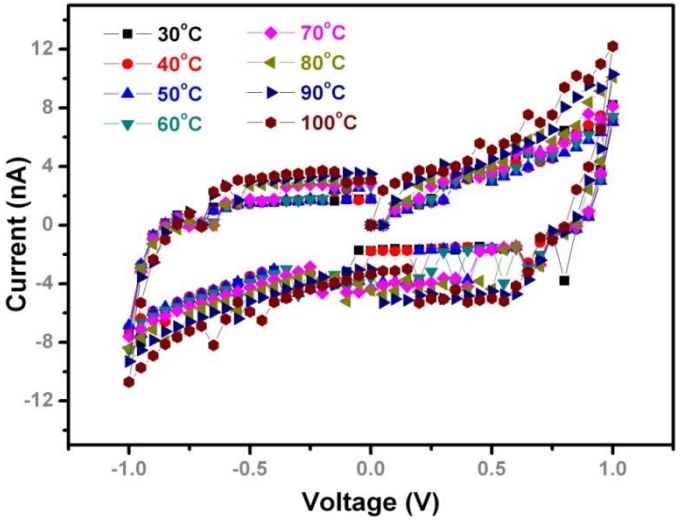
Polymer



TiO_2 nanorods

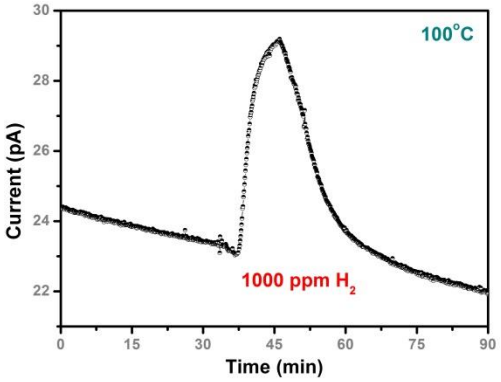


Polymer/TiO_2 nanorods

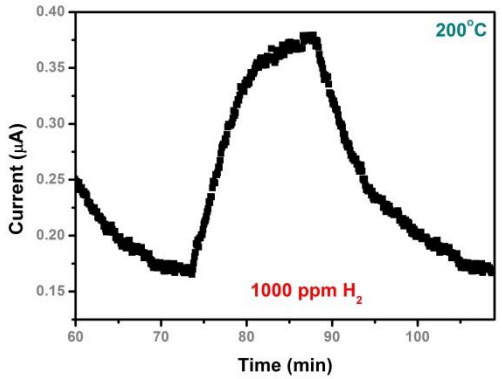


H_2 Sensing Properties of Polymer, TiO2 nanorods and heterostructure

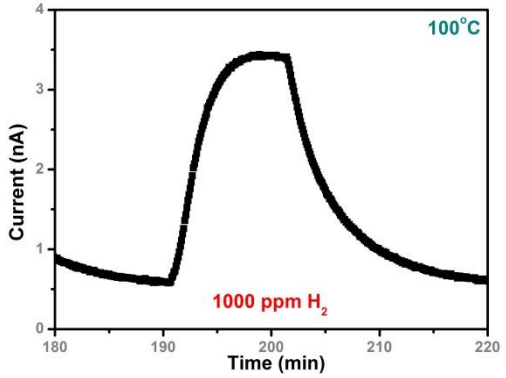
Polymer

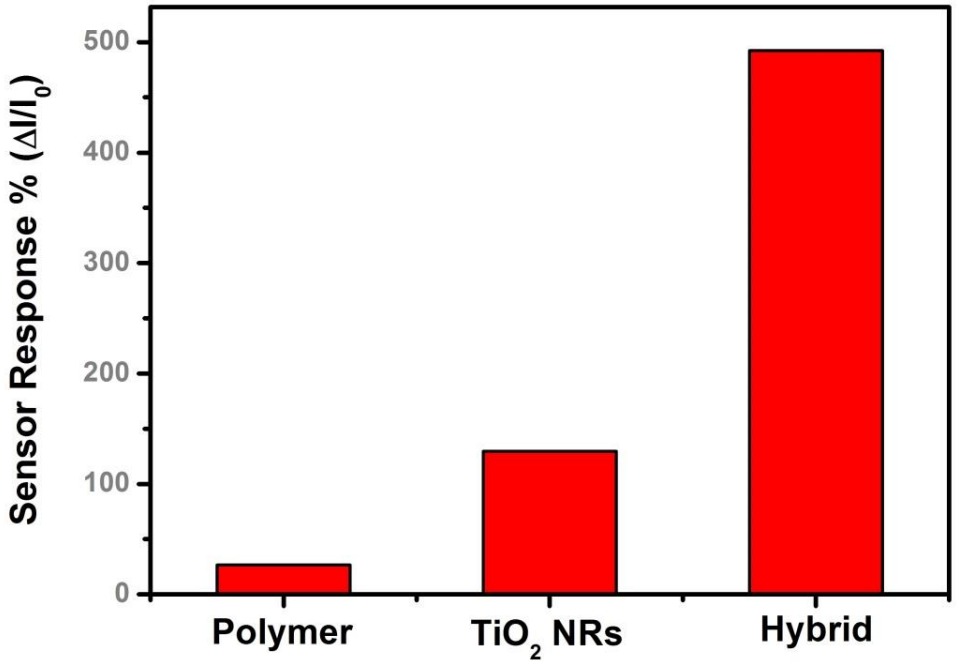


TiO_2 nanorods

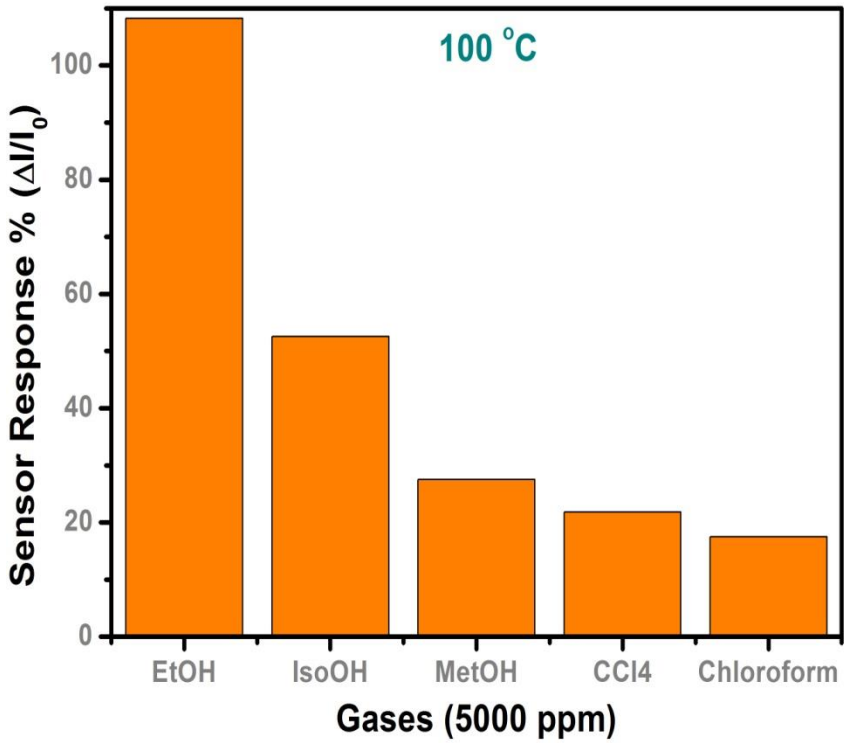


Polymer/TiO_2 nanorods





VOC Sensing Properties of Heterostructures



Conclusions

- Polymer thin film/TiO_2 nanorods heterostructures were fabricated for gas sensor application.
- Heterostructure device is more sensitive for isopropanol than TiO_2 nanorods device.
- Heterostructure device is more sensitive for H_2 than TiO_2 nanorods device and Polymer thin film.
- Working temperature is decreased to 100 ^oC. Even at room temperature, H_2 gas sensing of heterostructure device is obtained.

Acknowledgement

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Thank you for your attention !