The Fifth International Conference on Advances in Sensors, Actuators, Metering and Sensing
ALLSENSORS 2020

UV-assisted Chemiresistive Alcohol Sensor Based on Cobalt Doped Tin Dioxide

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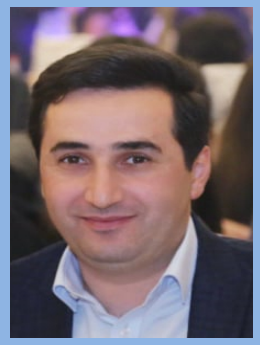
UV-assisted Chemiresistive Alcohol Sensor Based on Cobalt Doped Tin Dioxide

Presenter: **Mikayel S. Aleksanyan**



Education

2002-2006 - Yerevan State University, Faculty of Radiophysics, Bachelor

2006-2008 - Yerevan State University, Faculty of Radiophysics, MA

2008-2011 - Yerevan State University, Faculty of Radiophysics, PhD

Main research interest

Physics of semiconductors and semiconductor devices, semiconductor nanotechnologies

Current research activity

Semiconductor gas sensors, thin films manufacturing technology, PVD and CVD technologies, preparation and investigation of semiconductor gas sensors and biosensors made of nanostructured metal oxides and carbon nanotube-metal oxide nanocomposite materials.

Work experience

2006- up to now scientist researcher of YSU (Yerevan State University) Centre of Semiconductor Devices and Nanotechnologies.

2013- up to now head of educational laboratory of Department of Physic of Semiconductors and Microelectronics at Yerevan State University.

2013- up to now PR Officer of Faculty of Radiophysics.

Academic courses /Teaching and Training Experience

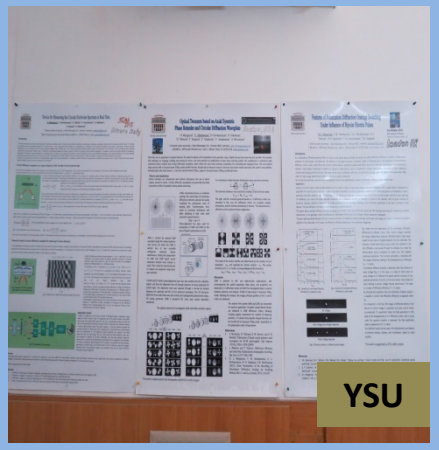
“Semiconductors Physics and Devices”, “Introduction of IC design and fabrication”, “Modelling of physical processes in semiconductors”, “Information technology in semiconductor physics”, “microelectronics” and so on.

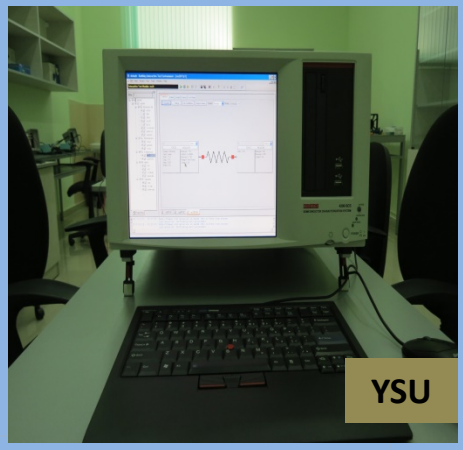
Publications

More than 40 publications and abstracts, 1 book as well as 3 patents.

Topic of research interest of our workgroup:

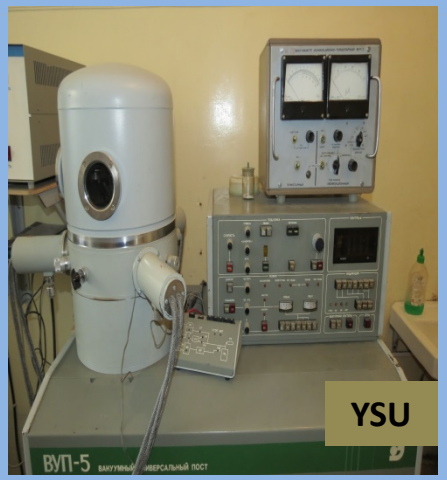
Preparation and investigation of semiconductor gas sensors and biosensors made of nanostructured metal oxides and carbon nanotube-metal oxide nanocomposite materials





CENTER OF SEMICONDUCTOR DEVICES AND NANOTECHNOLOGIES

Department of Physics of Semiconductors and Microelectronics at YSU



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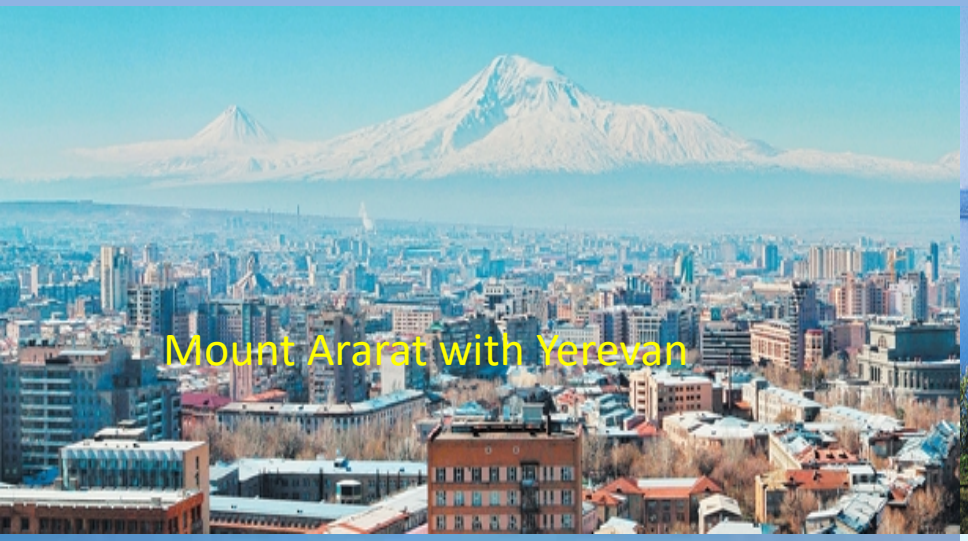
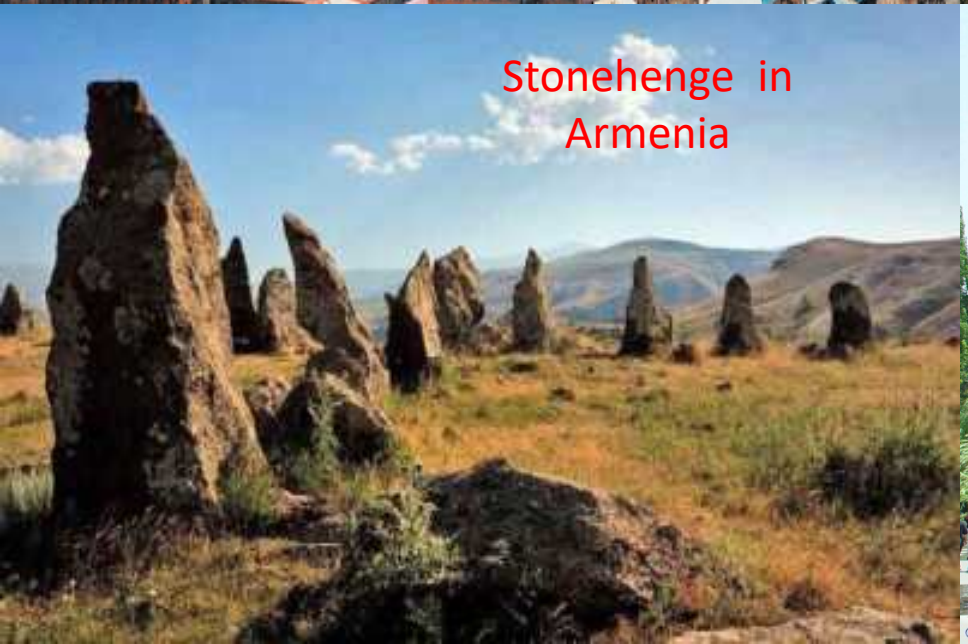
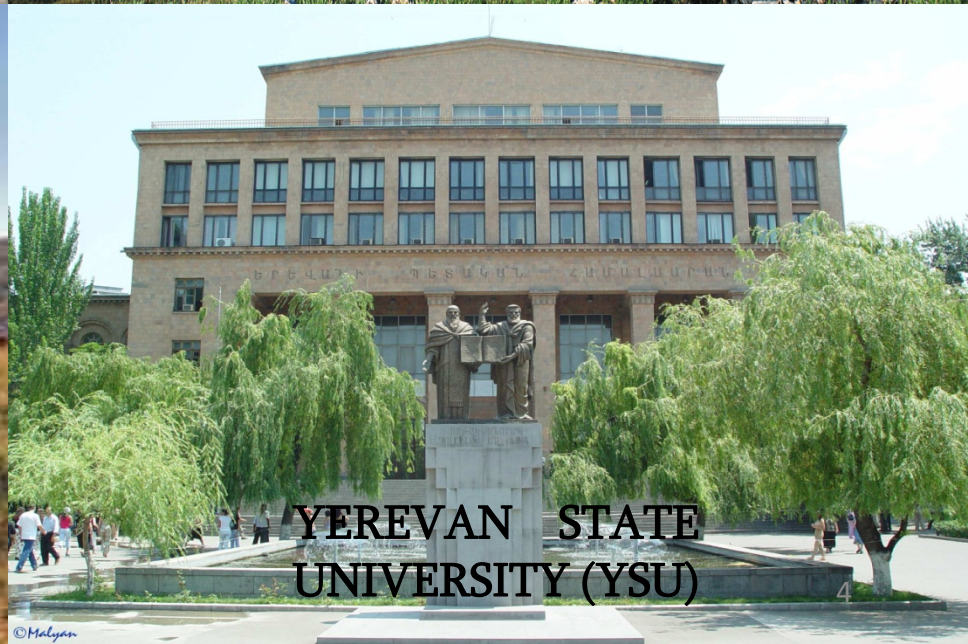
A R M E N I A





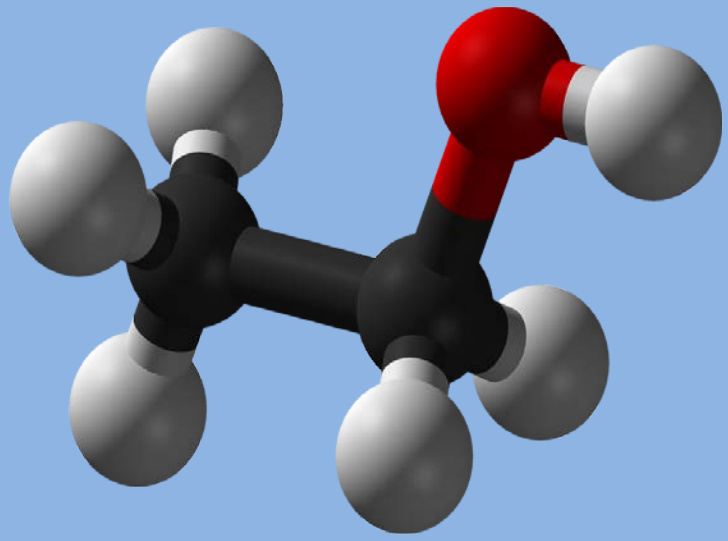


UV-assisted Chemiresistive Alcohol Sensor Based on Cobalt Doped Tin Dioxide

Alcohol (ethanol-C_2H_5OH)

The main fields of application

- *Industrial applications*
- *Medical applications*
- *Pharmaceutical applications*
- *As a fuel uses*
- *Domestic uses*
- *As an Alcoholic drink uses*
- *…*



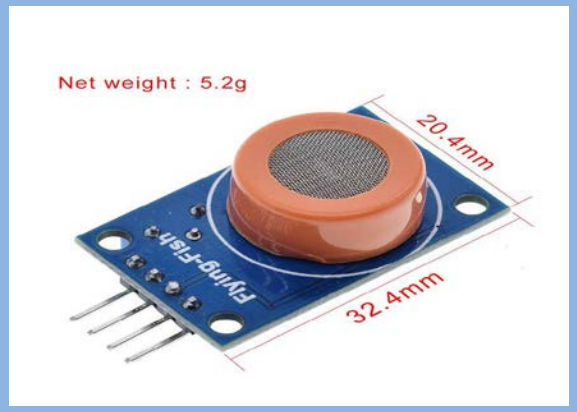
UV-assisted Chemiresistive Alcohol Sensor Based on Cobalt Doped Tin Dioxide

Available alcohol vapour sensors

(which do not partially meet the modern requirements)

A law enforcement grade breathalyzer, specifically an Alco-Sensor IV

LCD Digital Police Alcohol Breath Test Tester Analyzer Breathalyzer alcohol tester



TZT MQ-3 alcohol sensor module alcohol ethanol gas sensitive detection alarm for arduino

TGS3870-B00 Gas Sensor for the detection of both Methane and Carbon Monoxide

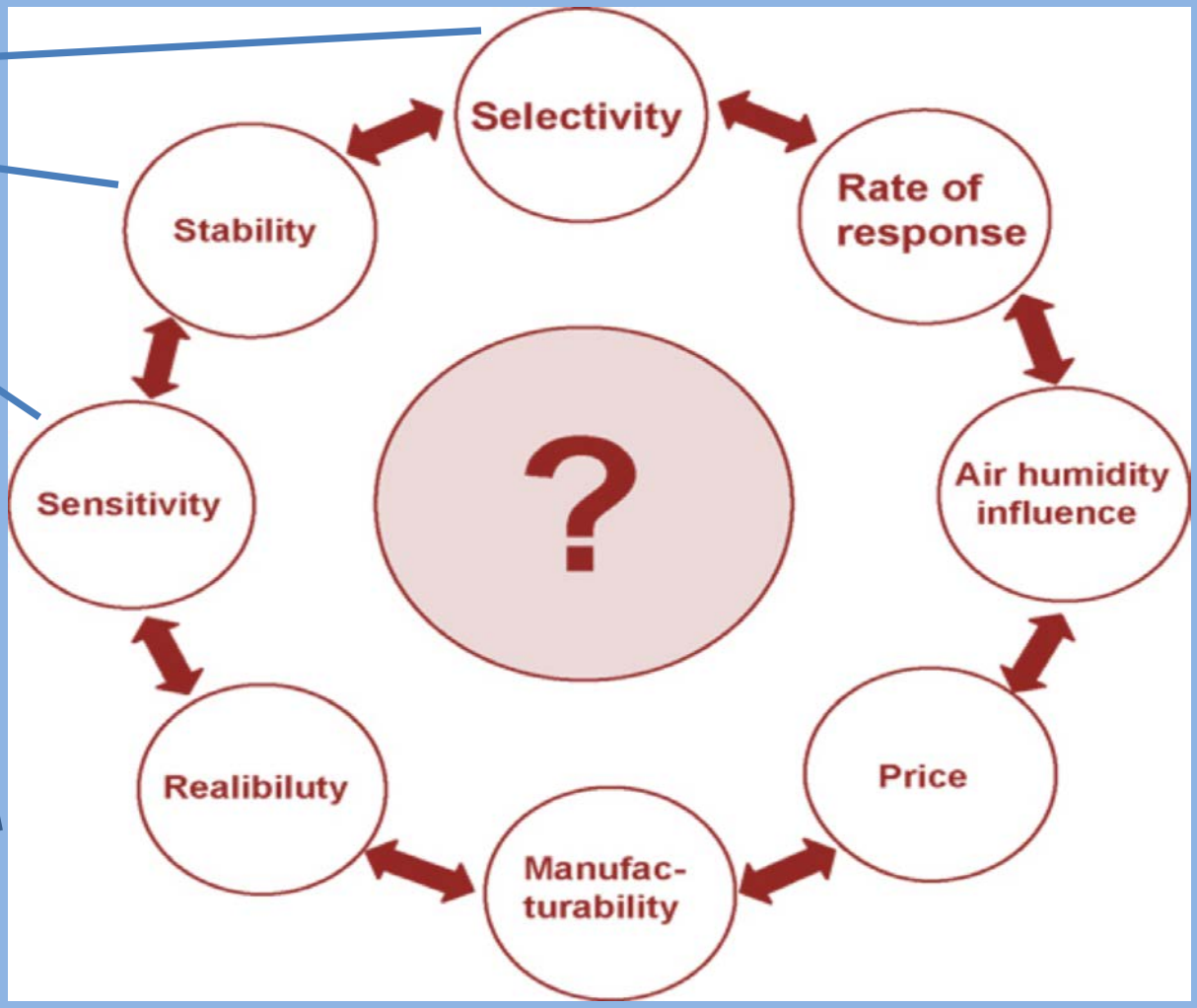
UV-assisted Chemiresistive Alcohol Sensor Based on Cobalt Doped Tin Dioxide

The main parameters of semiconductor gas sensors

3 "S" problems

High operating temperature

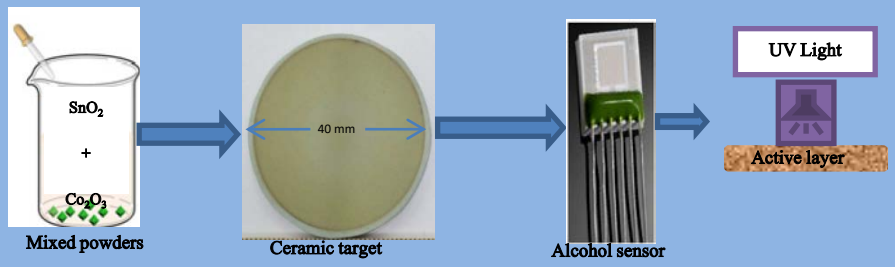
Not easy recovery



UV-assisted Chemiresistive Alcohol Sensor Based on Cobalt Doped Tin Dioxide

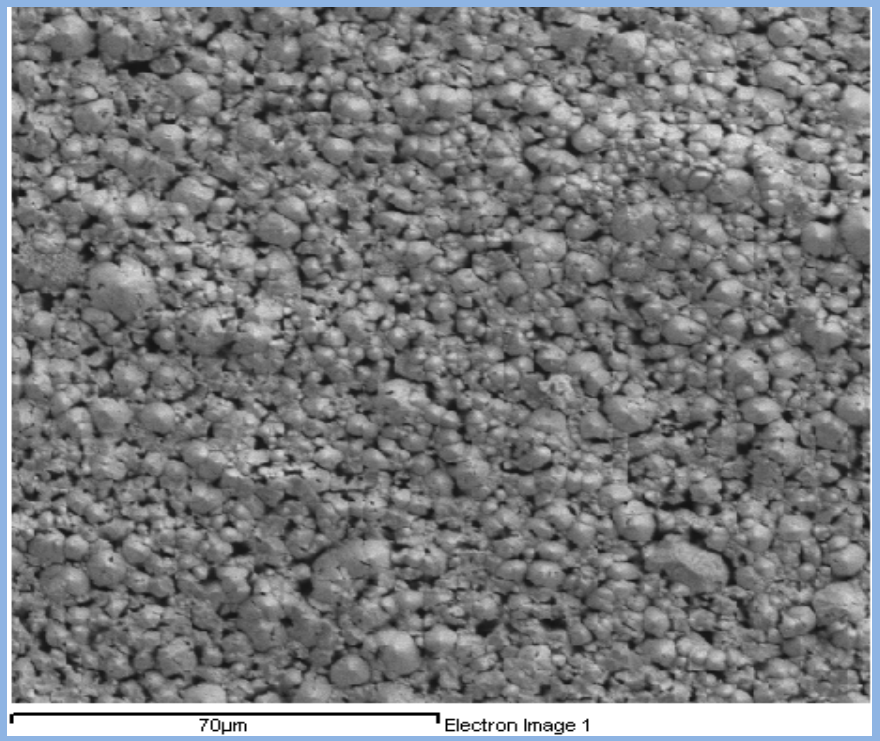
- *Experimental*

Ceramic target based on SnO_2 doped with 2at.% Co was synthesized by the method of solid-phase reaction in air. The annealing was carried out at 500°C-1100°C for the compacted sample SnO_2<Co>.



The photo of the SnO_2<Co> ceramic targets

The SEM image of the surface of the SnO_2<Co> ceramic target

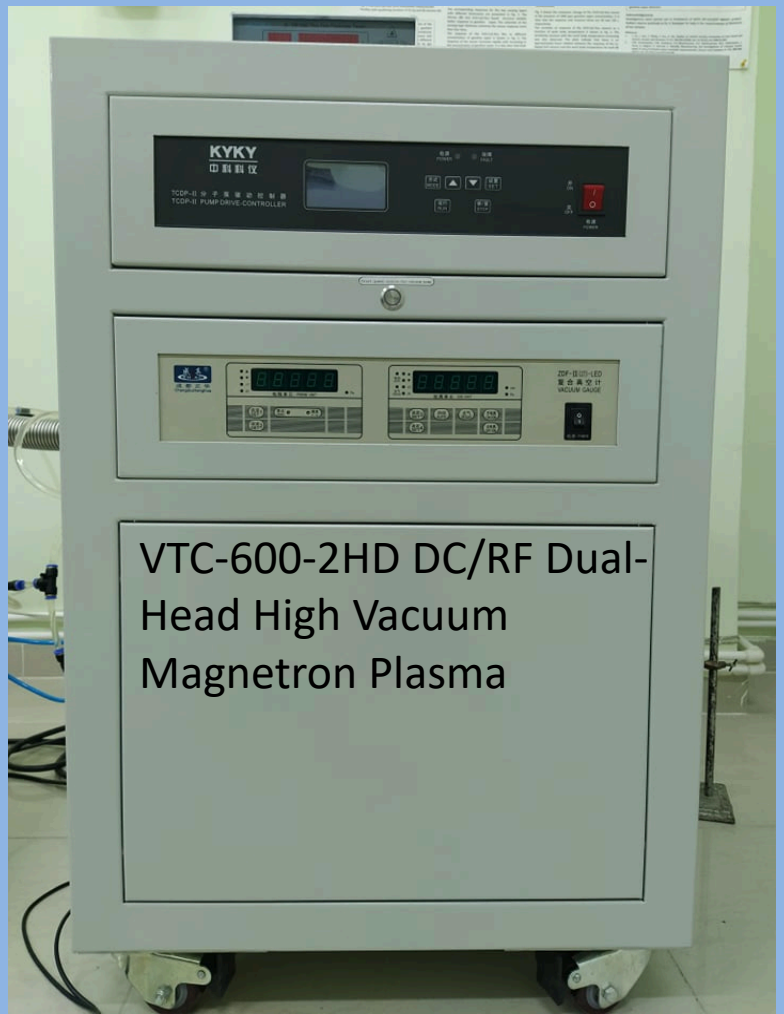


UV-assisted Chemiresistive Alcohol Sensor Based on Cobalt Doped Tin Dioxide

- *Experimental*

The prepared semiconductor SnO_2<Co> target with a diameter ~ 40 mm and thickness ~ 2 mm was used for deposition of nanosized films using the high-frequency magnetron sputtering method.

The photos of the high-frequency magnetron sputtering system

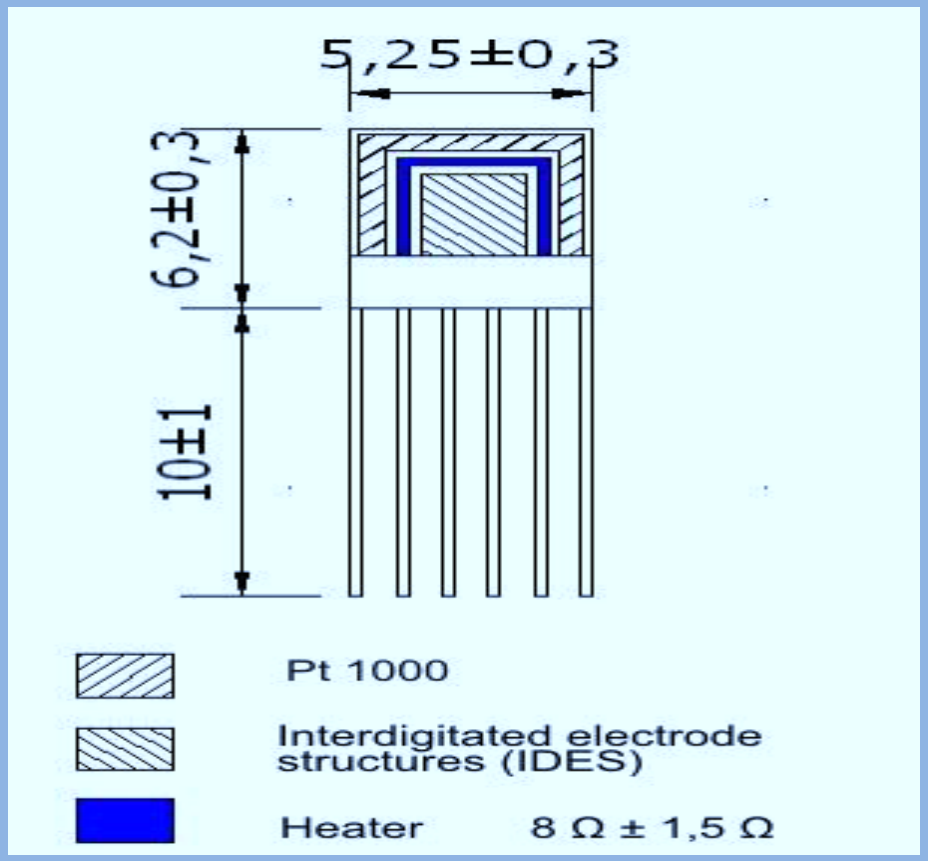


UV-assisted Chemiresistive Alcohol Sensor Based on Cobalt Doped Tin Dioxide

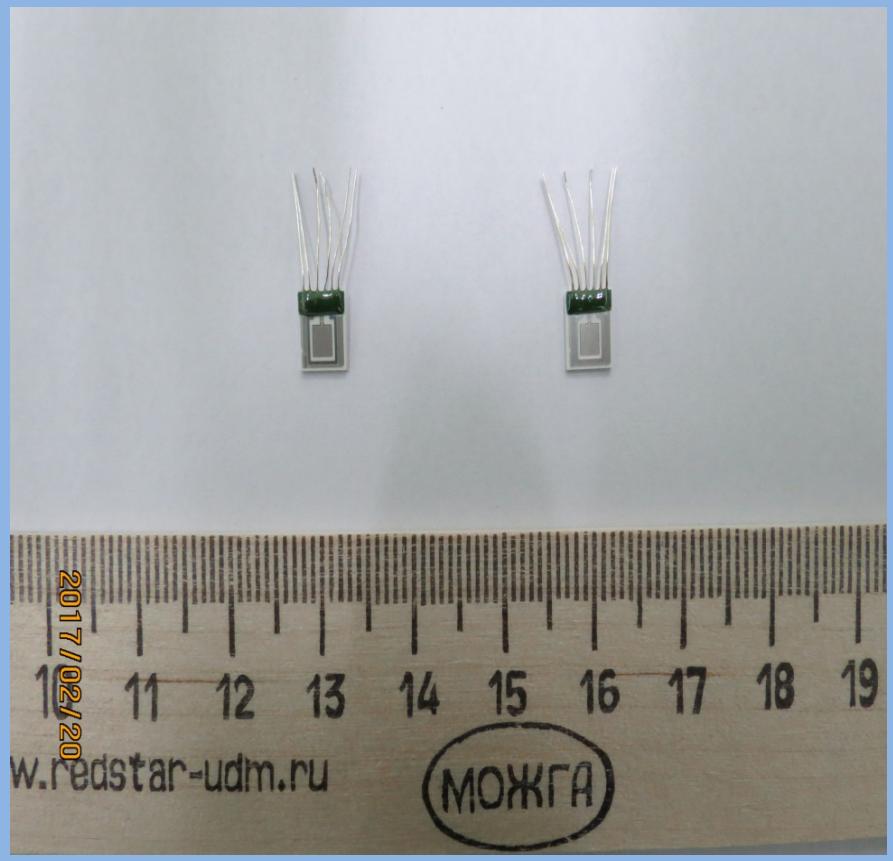
- *Experimental*

Multi-Sensor-Platforms (purchased from TESLA BLATNÁ, Czech Republic) are used as substrates.

The schematic image of the Multi-Sensor-Platform



The photo of the Multi-Sensor-Platforms based gas sensors



UV-assisted Chemiresistive Alcohol Sensor Based on Cobalt Doped Tin Dioxide

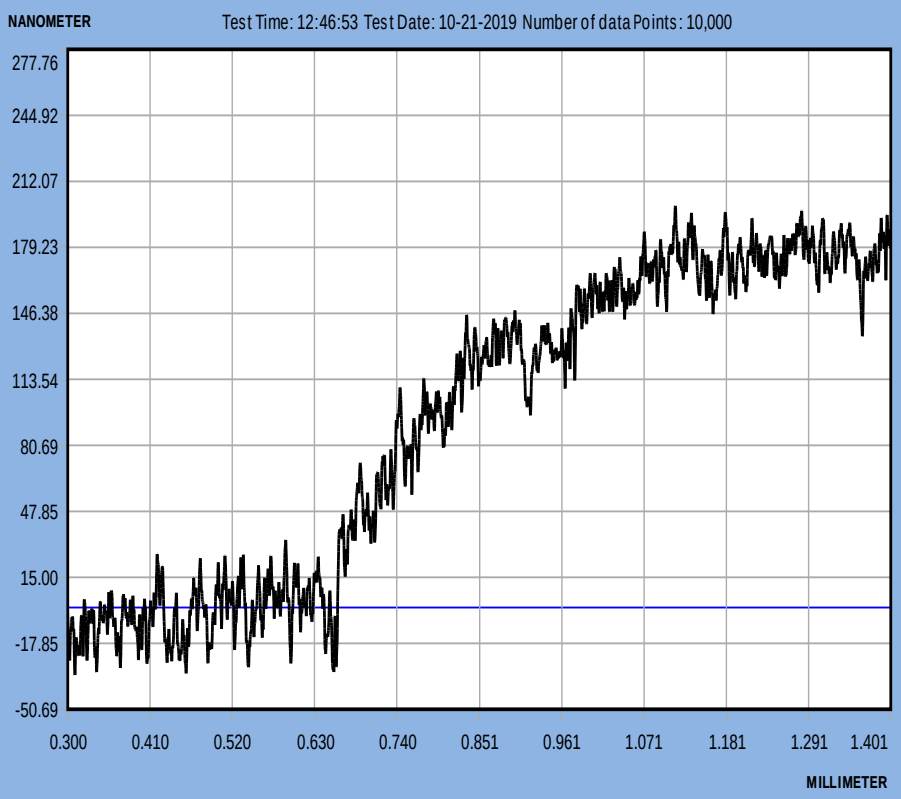
- ***Experimental***

The power of the magnetron generator unit was 60 W. The substrate temperature during sputtering was 200 °C. Duration of the sputtering process was equal to 20 minutes for SnO_2<Co> layer.

***The thicknesses of the deposited doped metal oxide films were measured by* Alpha-Step D-300 (KLA Tencor) profiler.**

The thicknesse of the SnO_2 doped with 2at.% Co film was equal to 180 nm.

The thicknesse measurement resulte for SnO_2 doped with 2at.% Co film



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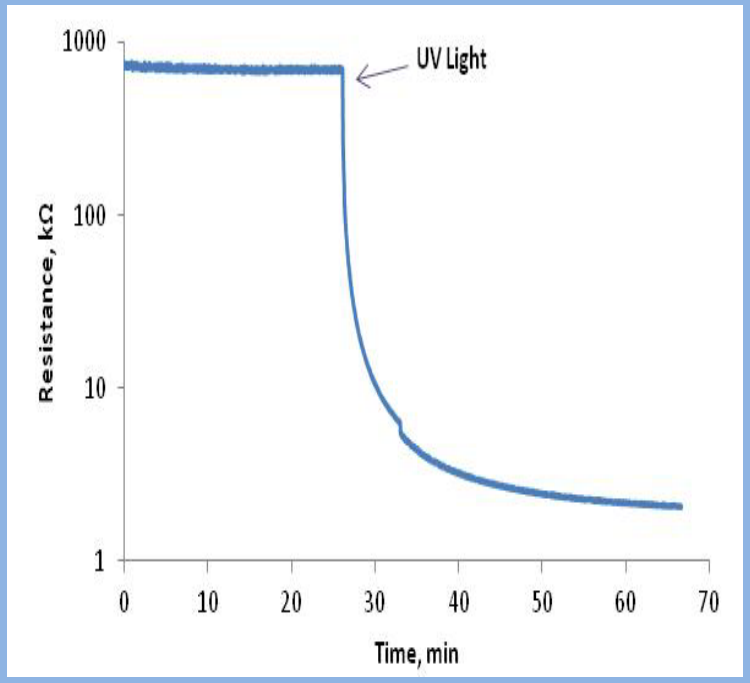
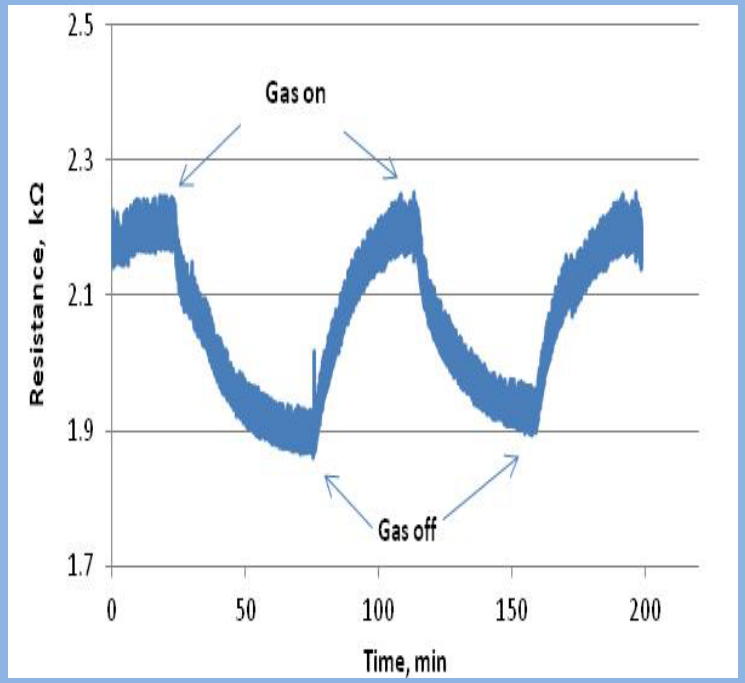
- ***Results***



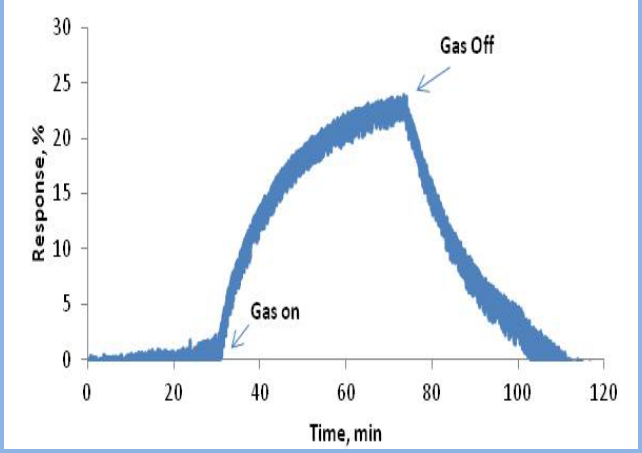
Resistance variation of the Co-doped SnO_2 sensing layer under the influence of UV irradiation at room temperature.



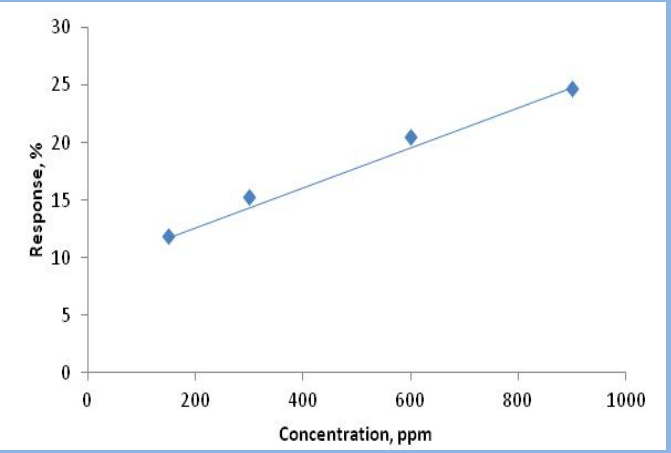
Resistance variation of the SnO_2<Co> sensor under the influence of UV irradiation at room temperature in the presence of 150 ppm ethanol vapors.

UV-assisted Chemiresistive Alcohol Sensor Based on Cobalt Doped Tin Dioxide

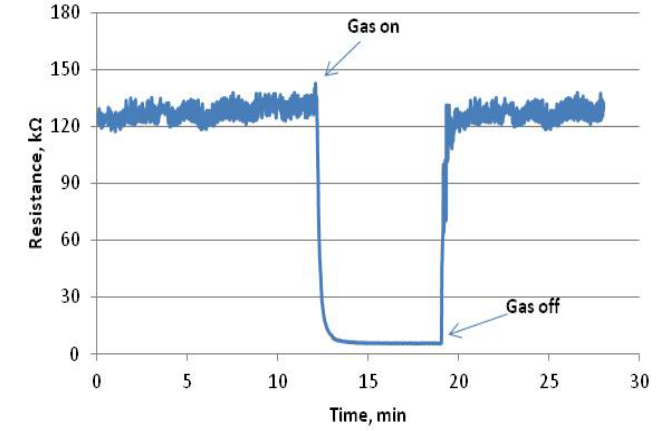
- ***Results***



The SnO_2<Co> sensor response to 900 ppm of ethanol vapors under the influence of UV irradiation at room temperature



The dependence of response on the ethanol vapor concentration under the influence of UV irradiation at room temperature



Resistance variation of the SnO_2<Co> sensor in the presence of 150 ppm ethanol vapors at 200 °C operating temperature in the dark

UV-assisted Chemiresistive Alcohol Sensor Based on Cobalt Doped Tin Dioxide

- *Sensing mechanism*

The sensors manufactured by us are resistive, i.e., its operation is grounded on changes of resistance of gas sensitive semiconductor layer under the influence of C_2H_5OH vapours caused by an exchange of charges between molecules of the semiconductor film and absorbed C_2H_5OH vapours.

The reactions of C_2H_5OH with the surface of the semiconductor

O_2 (gas) $\leftrightarrow$ O_2 (ads),

O_2 (ads) + e^- $\leftrightarrow$ O_2^- (ads),

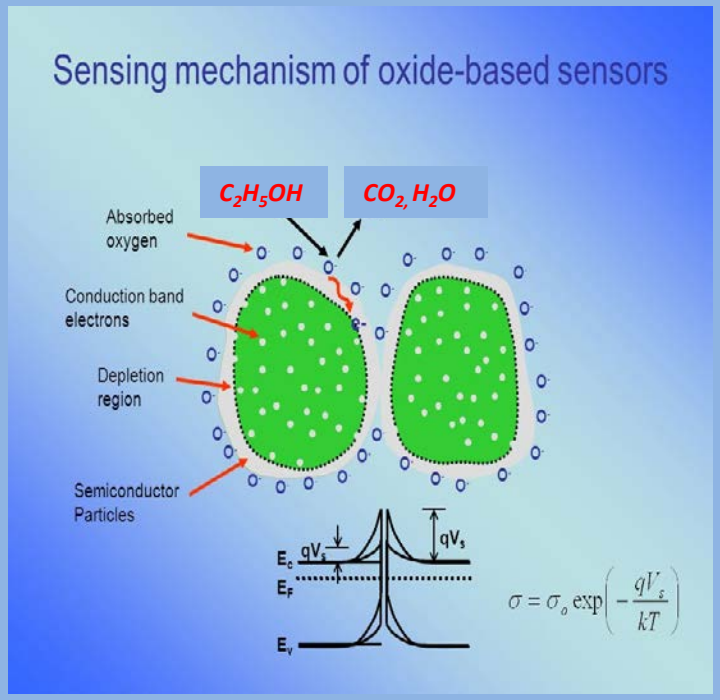
O_2^- (ads) + e^- $\leftrightarrow$ $2O^-$ (ads),

O^- (ads) + e^- $\leftrightarrow$ O^{2-} (ads).

$6O^- + C_2H_5OH(g) \rightarrow 3H_2O(g) + 2CO_2(g) + 6e^-$,

$3O_2^- + C_2H_5OH(g) \rightarrow 3H_2O(g) + 2CO_2(g) + 3e^-$,

$6O^{2-} + C_2H_5OH(g) \rightarrow 3H_2O(g) + 2CO_2(g) + 12e^-$.



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- ***Conclusion***

In summary, a simple technology has been used to manufacture semiconductor thin film sensors based on SnO_2 doped with 2 at.% Co. The fabricated SnO_2<Co> chemiresistive gas sensors showed a good sensitivity to different concentrations of ethanol vapor (from 150 to 900 ppm) at room temperature with the activation of low-powered UV LED (24 mW, 365 nm). The sensor displayed a good signal repeatability and long-term stability. These sensing characteristics made the present SnO_2<Co> based sensor a promising candidate for practically detecting ethanol vapors at room temperature.

- ***Acknowledgment***

This investigation was supported by 19YR-2K002 (Young Researchers 2019-2021) project of Ministry of Education, Science, Culture and Sport RA (Science Committee) .

THANK YOU FOR YOUR ATTENTION