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New Trends and Challenges for Air Quality Control

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ONE-DIMENSIONAL ZnO NANOSTRUCTURES AND THEIR OPTOELECTRONIC APPLICATIONS

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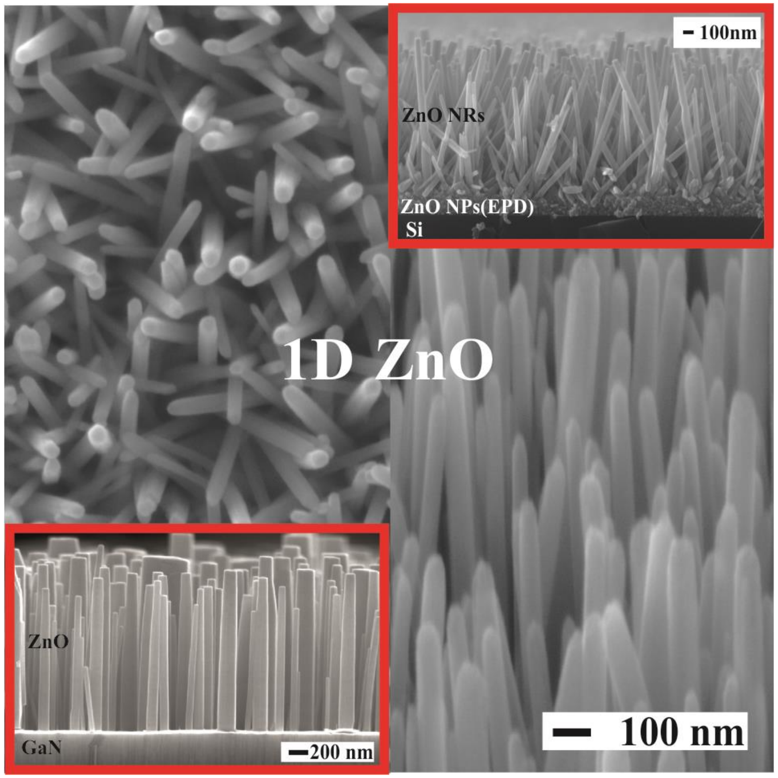
Introduction



Methods for the preparation

Gas phase methods:

- ✓ MOCVD;
- ✓ MBE.

Chemical or solution-base methods:

- ✓ Sol gel;
- ✓ Eelectrodeposition;
- ✓ Hydrothermal growth.

advantages:

- ✓*low growth temperature,*
- ✓*allows for the large scale production,*
- ✓*low cost,*
- ✓*flexibility in the selection of the substrate, etc.*

disadvantages:

- ✓*low quality*
- ✓*seed layer*

- ✓ Annealing in different ambient (vacuum, hydrogen, argon, air, nitrogen);
- ✓ Doping.

- ✓ Magnetron sputtering;
- ✓ Pulsed laser deposition;
- ✓ Spin coating;

Our solution:

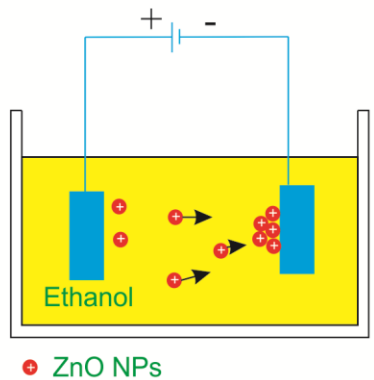
- ✓ Electrophoretic deposition.

Applications:

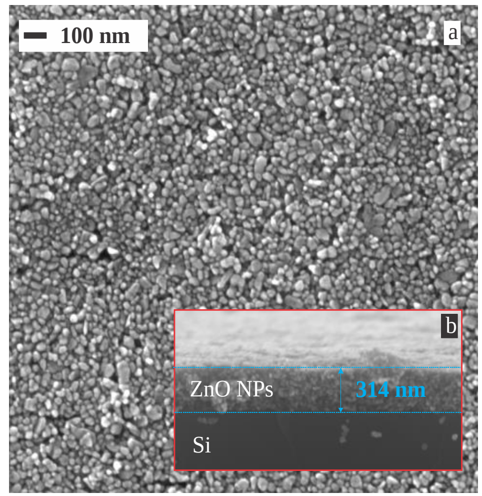
- ✓ Gas sensors;
- ✓ Field effect transistors;
- ✓ Energy harvesting devices;
- ✓ Light emitting devices.

Preparation of the seed layer

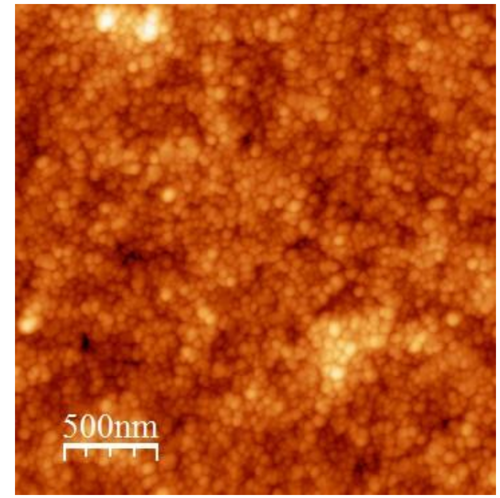
Electrophoretic deposition.



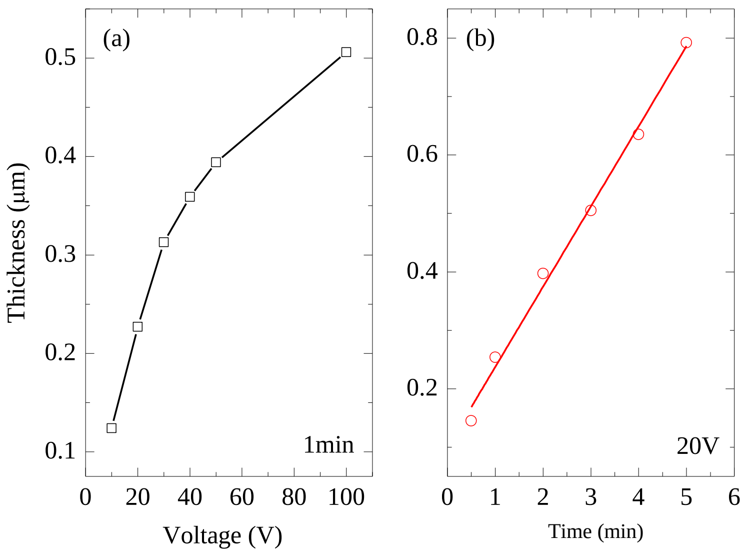
SEM images of ZnO NPs prepared by EPD. (a) top view, (b) cross section.



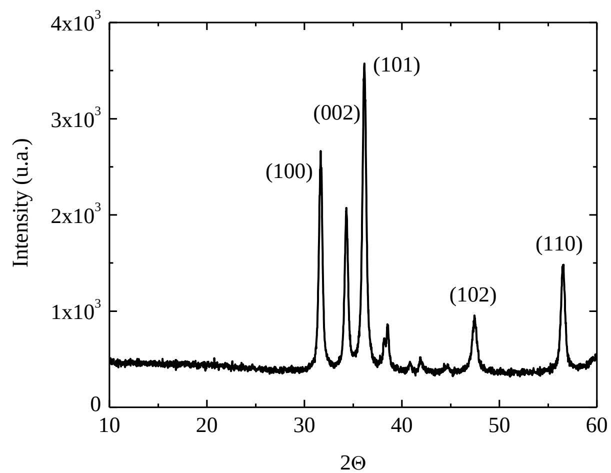
AFM image of ZnO NPs prepared by EPD.



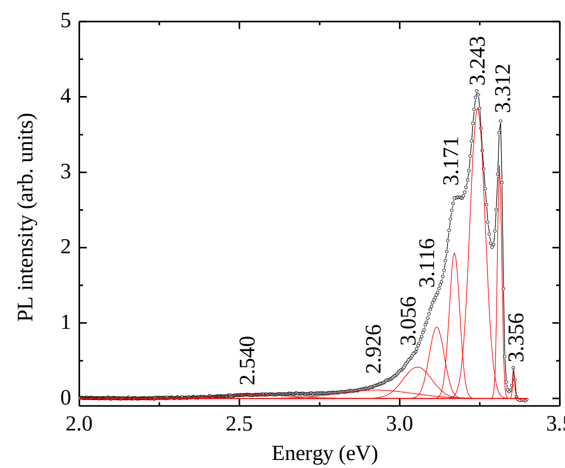
Relationship between the ZnO NP layer thickness and (a) applied voltage, (b) deposition time.



X-ray diffraction pattern.



4 K photoluminescence spectrum.



R. Yatskiv, J. Grym, P. Gladkov, O. Cernohorsky, J. Vanis and J.H.Dickerson, **Solid State Electron** (submited)

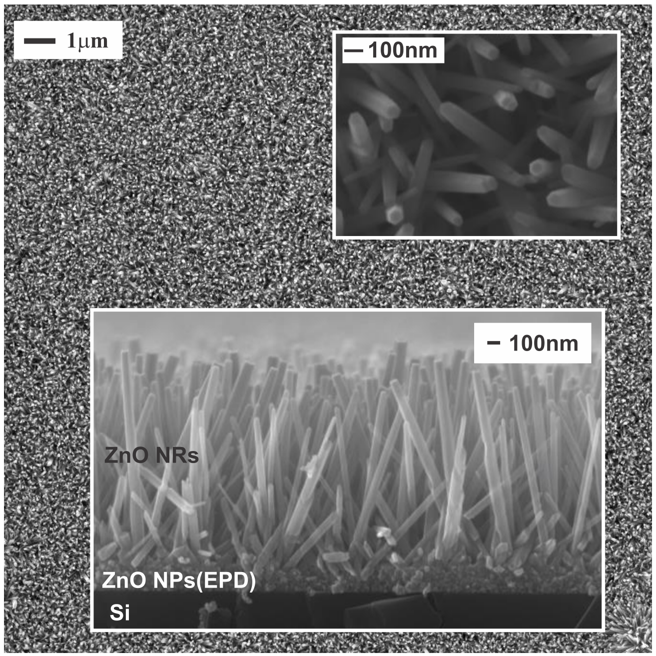
Preparation of the ZnO NRs

Hydrothermal growth (95°C, 3h)

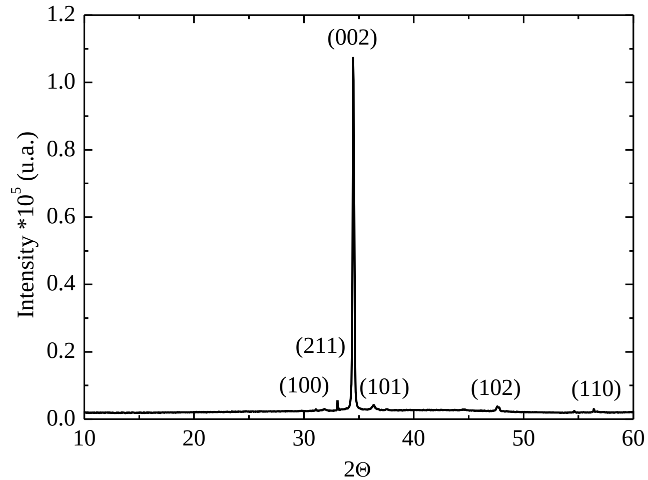
Zinc nitrate $\{Zn(NO_3)_2 * 6H_2O(NO_3)\}$

HMTA $\{C_6H_{12}N_4\}$

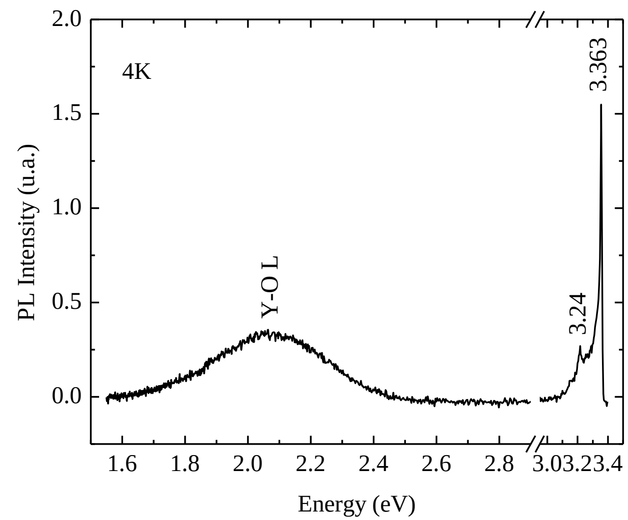
SEM images of ZnO NRs



X-ray diffraction pattern.



4 K photoluminescence spectrum.

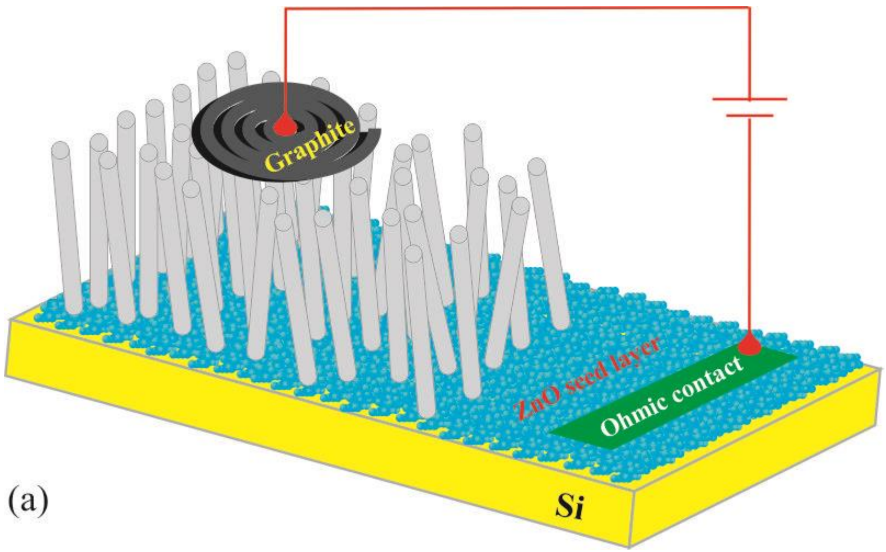


R. Yatskiv, J. Grym and M. Verde, **Solid State Electron** 105, 70-73 **(2015).**

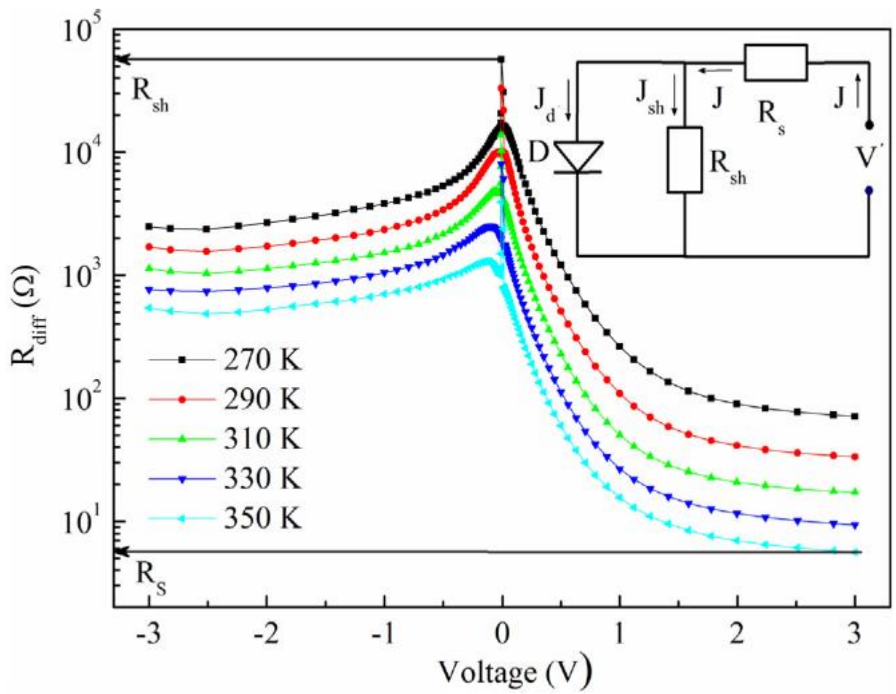
R. Yatskiv, V. V. Brus, M. Verde, J. Grym and P. Gladkov, **Carbon** 77, 1011-1019 **(2014).**

Electrical characterization of ZnO nanorods

Schematic cross section of the graphite/ZnO NRs junction.



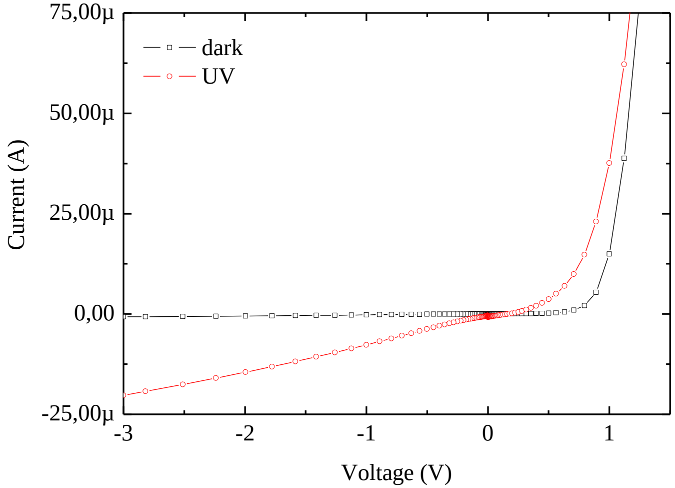
Differential resistance Rdiff of the graphite/ ZnO NRs heterojunctions vs. voltage. The inset shows the equivalent DC circuit.



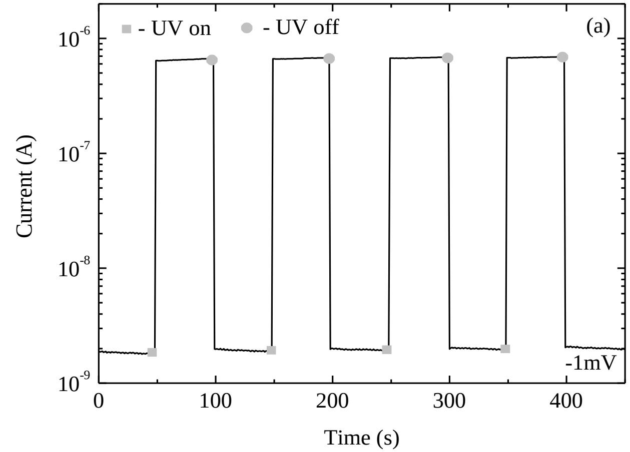
R. Yatskiv, V. V. Brus, M. Verde, J. Grym and P. Gladkov, **Carbon** 77, 1011-1019 **(2014).**

Graphite/ZnO NRs junction for UV photodetectors

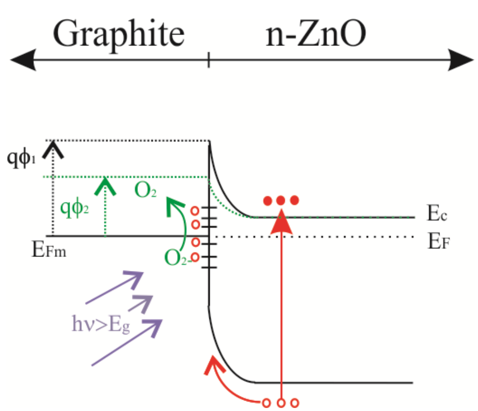
I-V characteristics of the graphite/ZnO NRs junction measured in darkness and under UV illumination



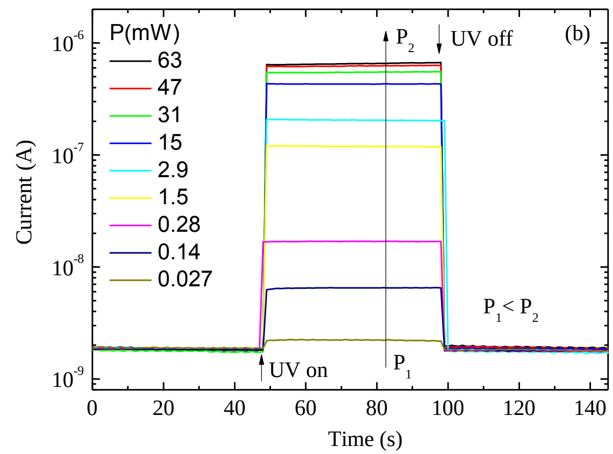
Time dependent photoresponse of the graphite/ZnO NRs at a reverse bias 1 mV under UV illumination with 395nm light for 4 cycles.



Schematic diagram of the working principle of the graphite/ZnO NRs junction UV photodetector



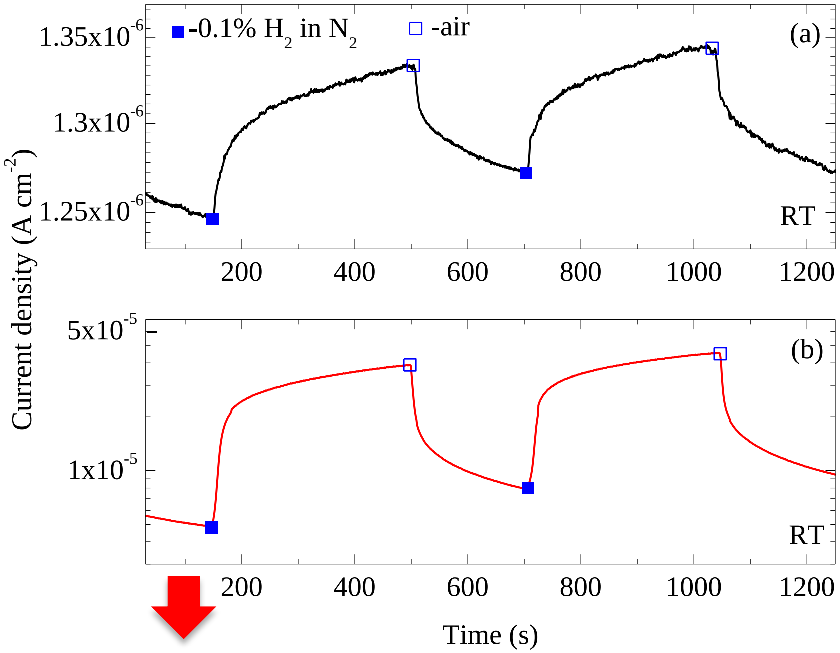
Photoresponse under various UV illumination intensities at a reverse bias of 1 mV.



R. Yatskiv, J. Grym and M. Verde, **Solid State Electron** 105, 70-73 **(2015).**

Graphite/ZnO NRs and Graphite-Pt NPs/ZnO NRs junction for gas sensors

Current transient characteristics of (a) the graphite/ZnO NRs junction, and (b) the graphite Pt NPs/ZnO NRs junction measured at -0.1 V.

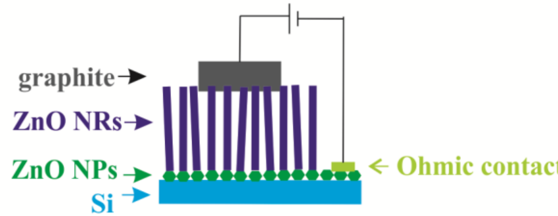


Type 1: Graphite/ZnO NRs junction

Sensitivity response (S): 7%;

Reponse time (τ_a): 81s;

Recovery time (τ_b): 47s.



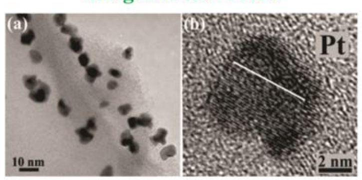
Type 2: Graphite-Pt/ZnO NRs junction

Sensitivity response (S): 700%;

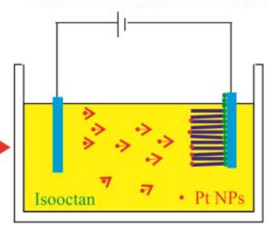
Reponse time (τ_a): 68s;

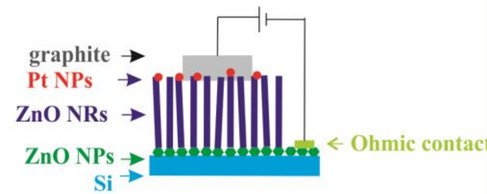
Recovery time (τ_b): 22s.

(a) TEM and (b) HRTEM images of thePt NPs



EPD Pt NPs on ZnO NRs





R. Yatskiv, J. Grym, V. V. Brus, O. Cernohorsky, P. D. Maryanchuk, C. Bazioti, G. P. Dimitrakopulos and P. Komninou, **Semicond Sci Tech** 29 (4), 045017 **(2014)**.

R. Yatskiv, J. Grym, P. Gladkov, O. Cernohorsky, J. Vanis and J.H.Dickerson, **Solid State Electron** (submitted)

CONCLUSIONS

- ✓ Arrays of ZnO NRs were prepared by hydrothermal growth on electrophoretically deposited seed layers of ZnO nanoparticles.
- ✓ Colloidal graphite was deposited on top of these arrays to form a Schottky barrier.
- ✓ The Schottky barrier was employed in highly-sensitive self-powered UV photodetectors and hydrogen sensors.
- ✓ When the NR arrays were decorated with Pt nanoparticles, the hydrogen sensing response was improved by a factor of 100, and faster recovery and response times were achieved.

Acknowledgment

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