

COST

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

COST Action TD1105

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New Sensing Technologies for Indoor and Outdoor Air Quality Control

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NANOSTRUCTURED SCHOTTKY CONTACTS FOR GAS SENSORS



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Outline

✓ Introduction

- Hydrogen
- Schottky-based semiconductor hydrogen sensors

✓ Experimental results and discussion

- Structures with catalytic metal NPs
- Preparation and characterization of metal NPs
- Electrophoretic deposition of metal NPs
- Electrical characterization and sensing properties

✓ Conclusions

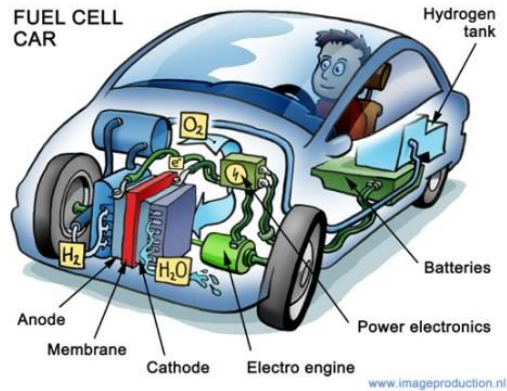
Hydrogen

Medicine



- Colorless, tasteless and odorless
- Extremely reactive with oxygen and other oxidizers
- Low ignition energy
- High flame temperature
- Invisible flame in daylight conditions (flame's low emissivity)
- Negative Joule-Thomson coefficient; leaking gas warms itself and may spontaneously ignite
- Small molecular size promotes leaks and diffusion
- Wide range between lower and upper flammability limits in air mixtures
- High flame speed

Hydrogen-fuelled vehicles



Chemical industry



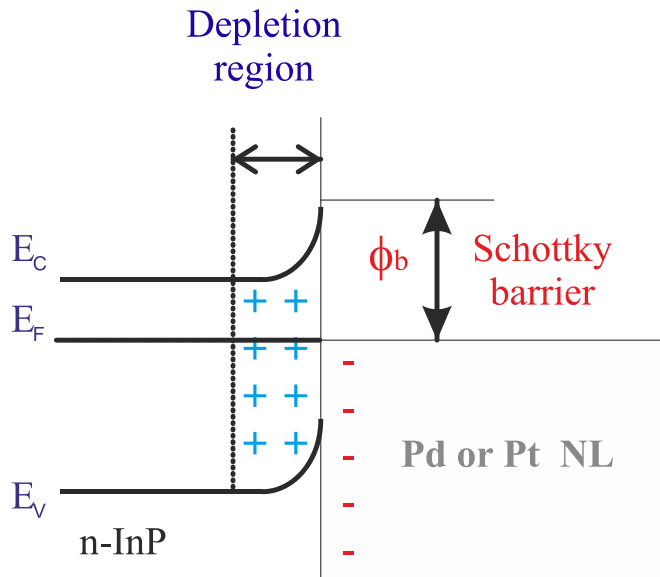
Small leakage of high concentration of hydrogen-containing gases can cause explosion.



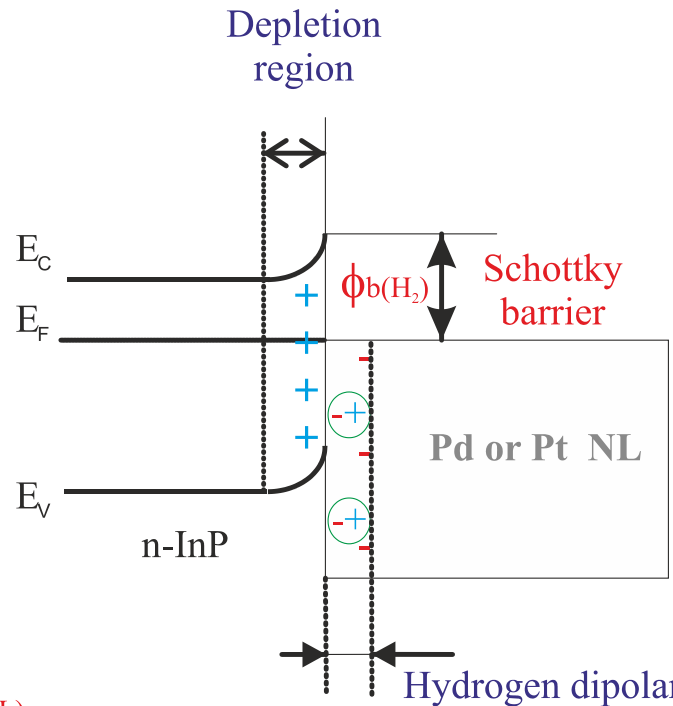
- ✓ high sensitivity,
- ✓ short response time,
- ✓ small size,
- ✓ low cost.

Semiconductor gas sensors

Schottky-based semiconductor sensors



Without H_2



With H_2

$$\phi_b > \phi_{b(H_2)}$$

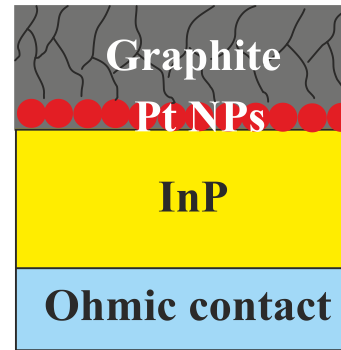
Schottky-based semiconductor sensors on InP

- Conventional evaporation, maximum SBH 0.5 eV, largely insensitive to the applied metal.
- Disordered interface – DIGS - Fermi level pinning
- Electroless plating.
- Electrochemical deposition of NPs.
- Our solution: EPD of NPs, colloidal graphite.

Structure Types



R. Yatskiv, J. Grym, V. V. Brus, O. Cernohorsky, P.D. Maryanchuk, C. Bazioti, G. P. Dimitrakopoulos, Ph. Komninou: *Semicond. Sci. Technol.* 2014; 29:045017.

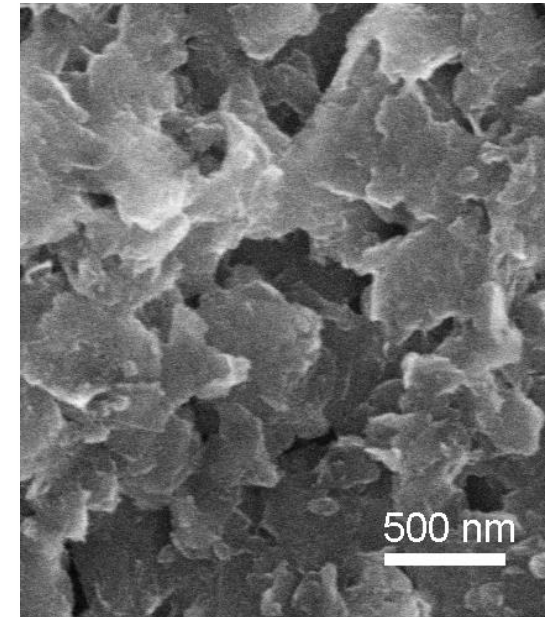
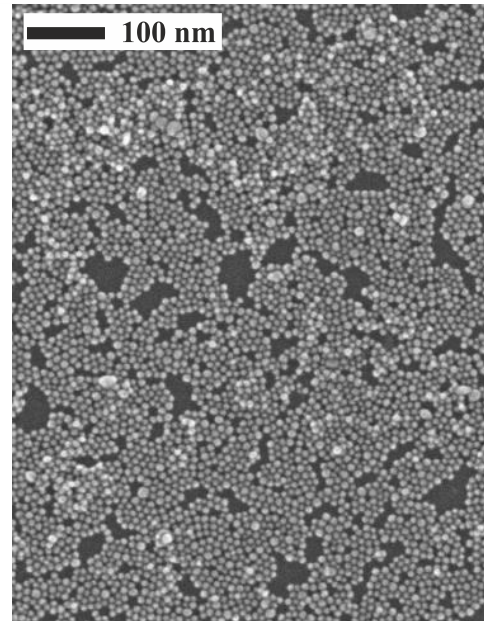
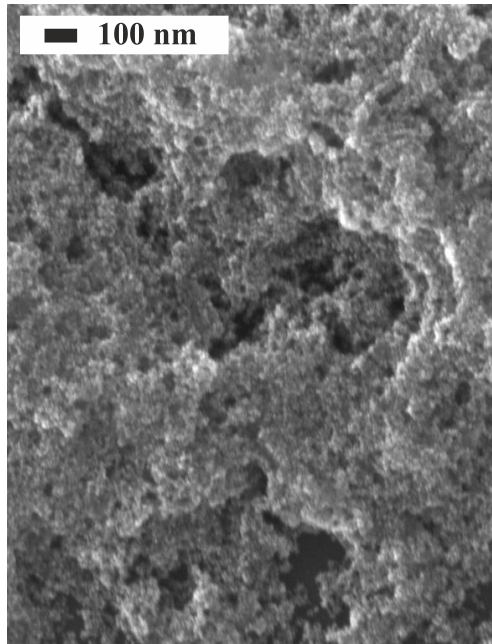


J. Grym, R. Yatskiv: *Semicond. Sci. Technol.* 2013;28:045006

R. Yatskiv, J. Grym, K. Zdansky, K. Piksova: *Carbon* 2012; 50(10):3928–3933.

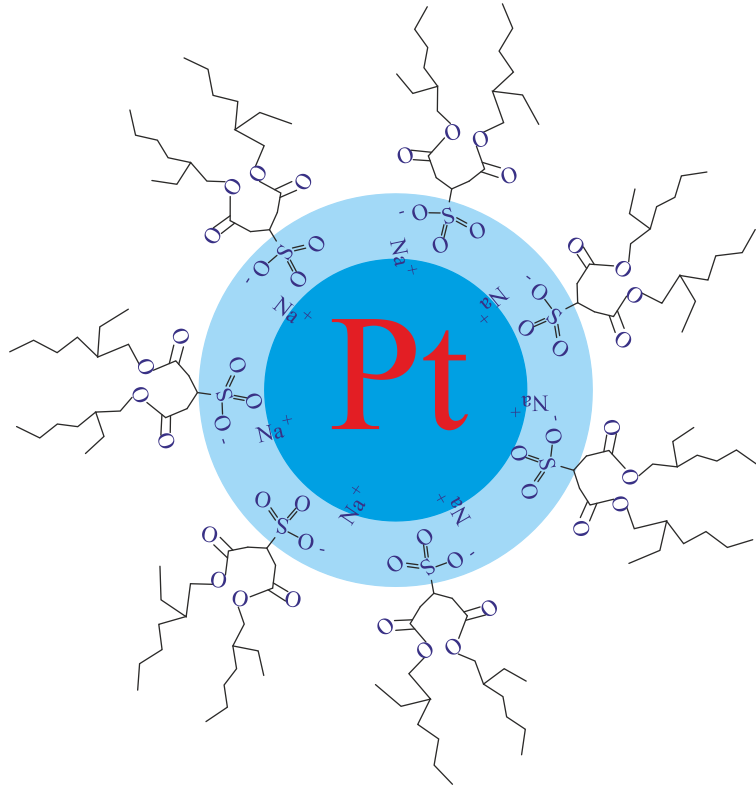
K. Zdansky, R. Yatskiv: *Sens. Actuator B-Chem.* 2012;169(1):104-109.

J. Grym, O. Prochazkova, R.Yatskiv, K. Piksova: *Nanoscale Res. Lett.* 2011; 6:392.



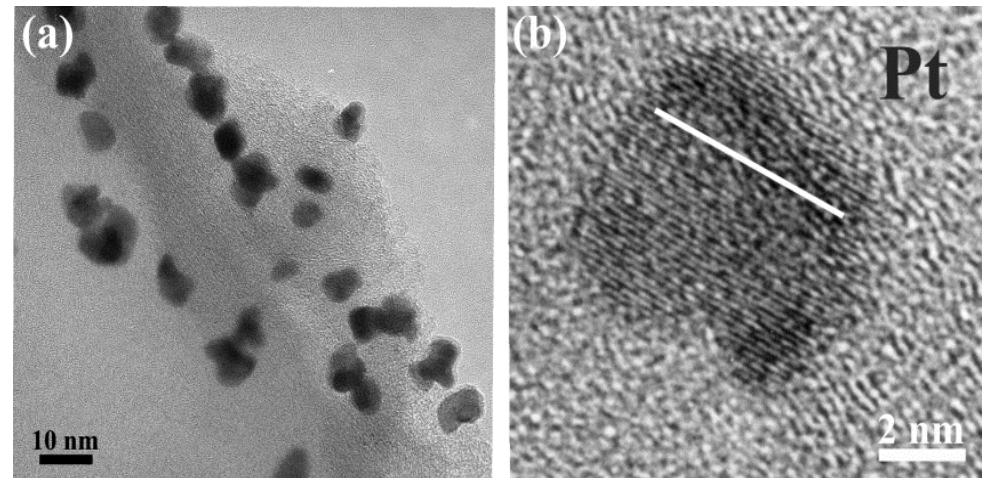
Preparation and characterization of Pt NPs

Preparation of Pt NPs by the reverse micelle technique.

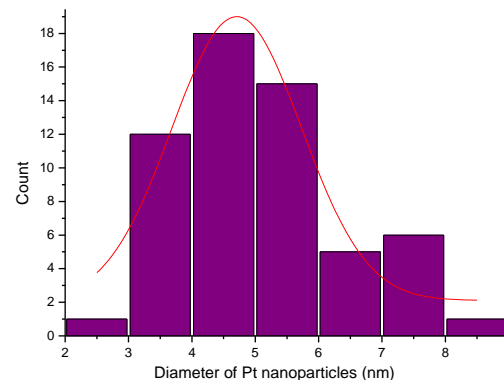


Characterization by optical extinction, dynamic light scattering, electron microscopy

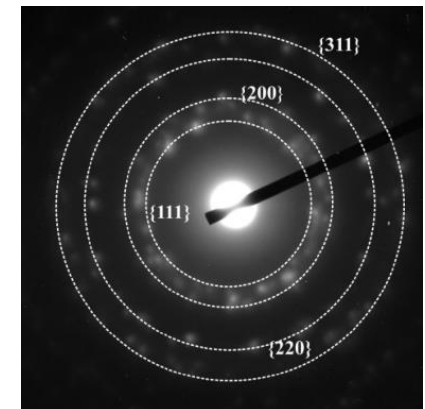
TEM images of the Pt NPs.



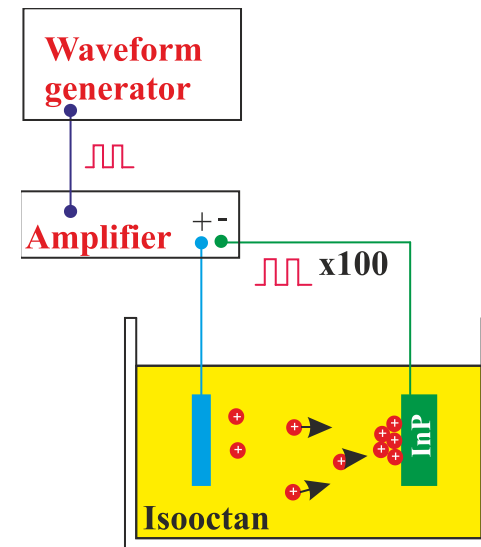
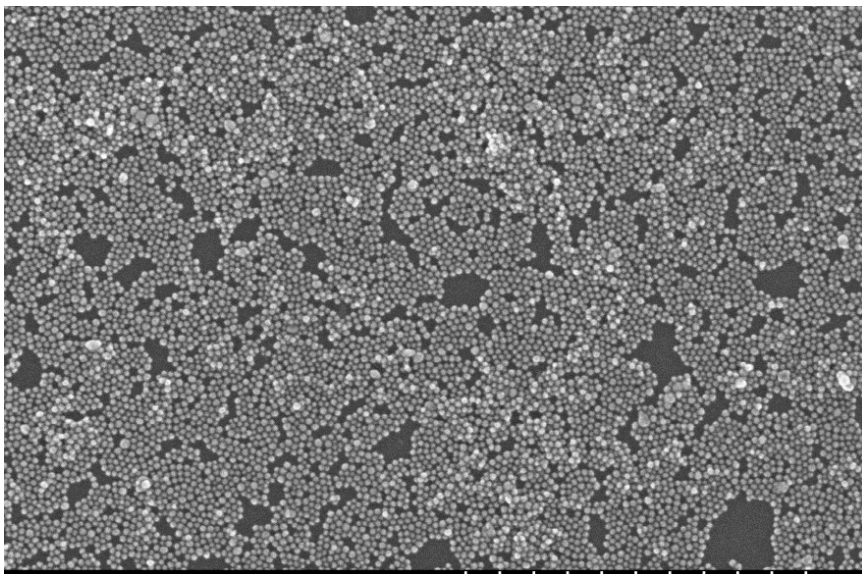
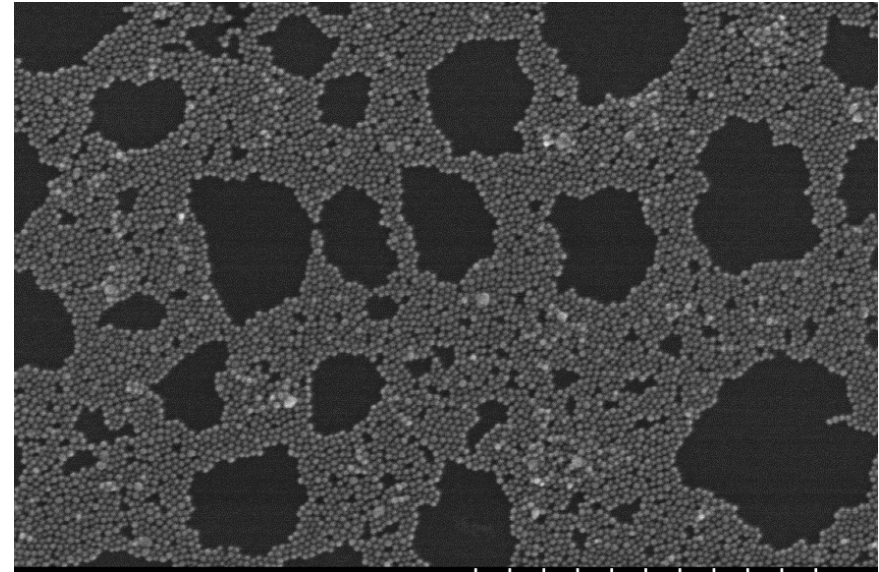
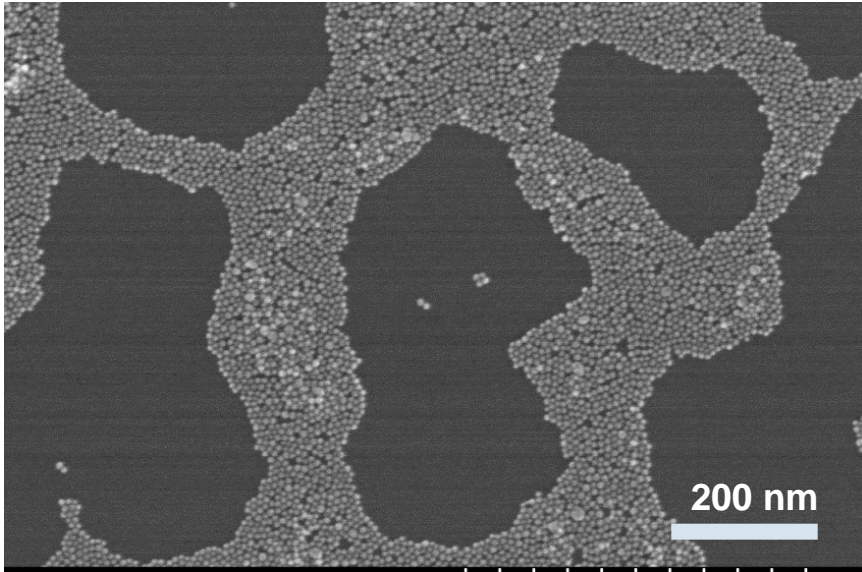
Histogram and Gaussian distribution from TEM.



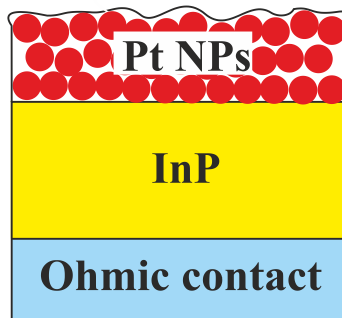
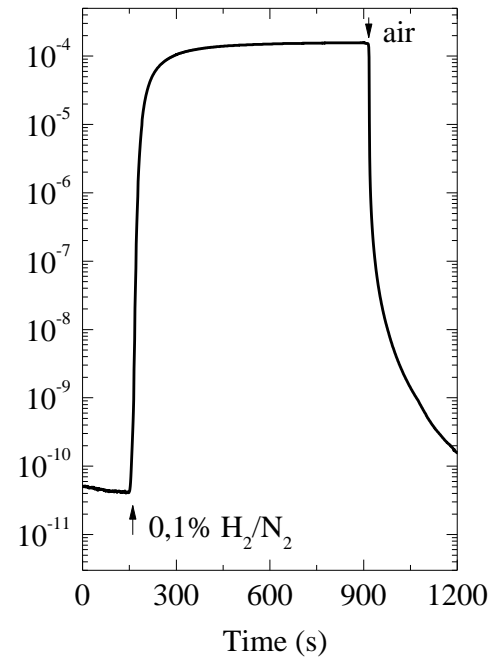
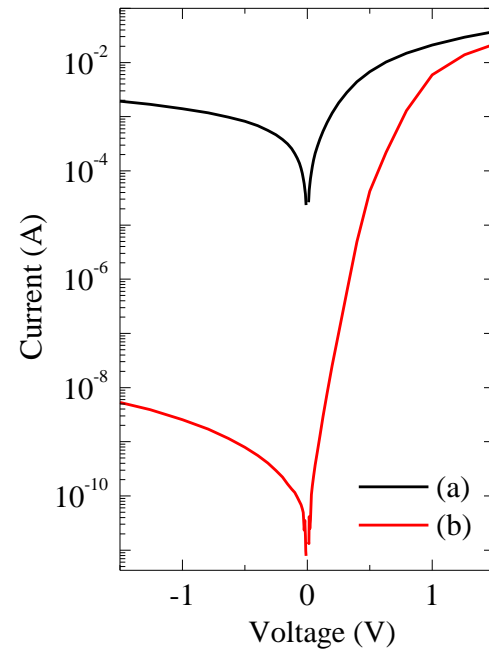
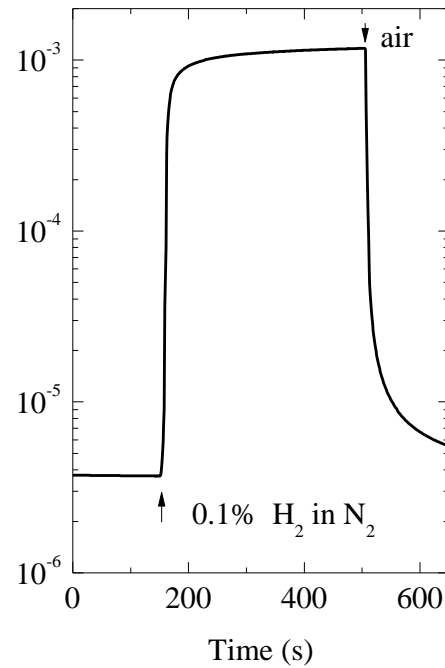
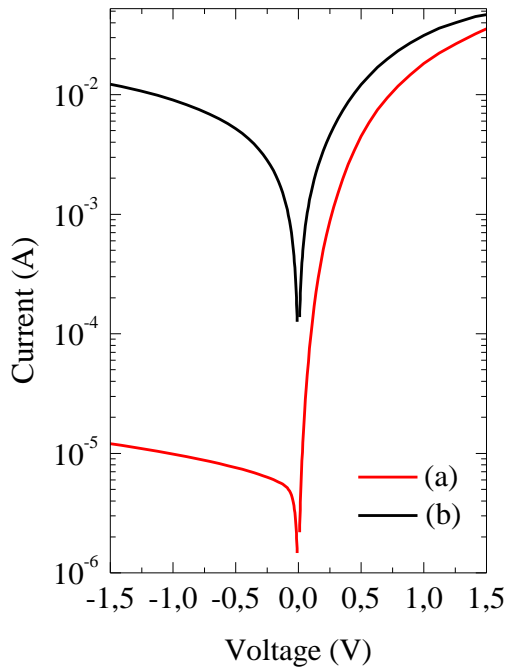
Electron diffraction.



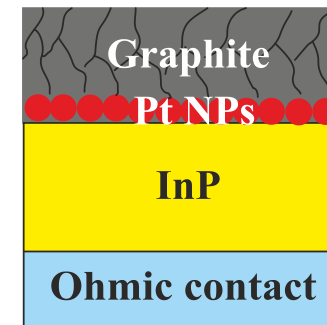
Electrophoresis



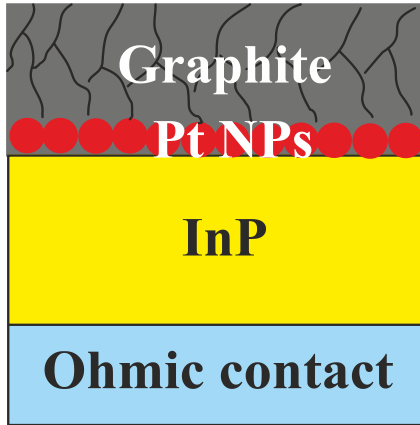
Electrical properties



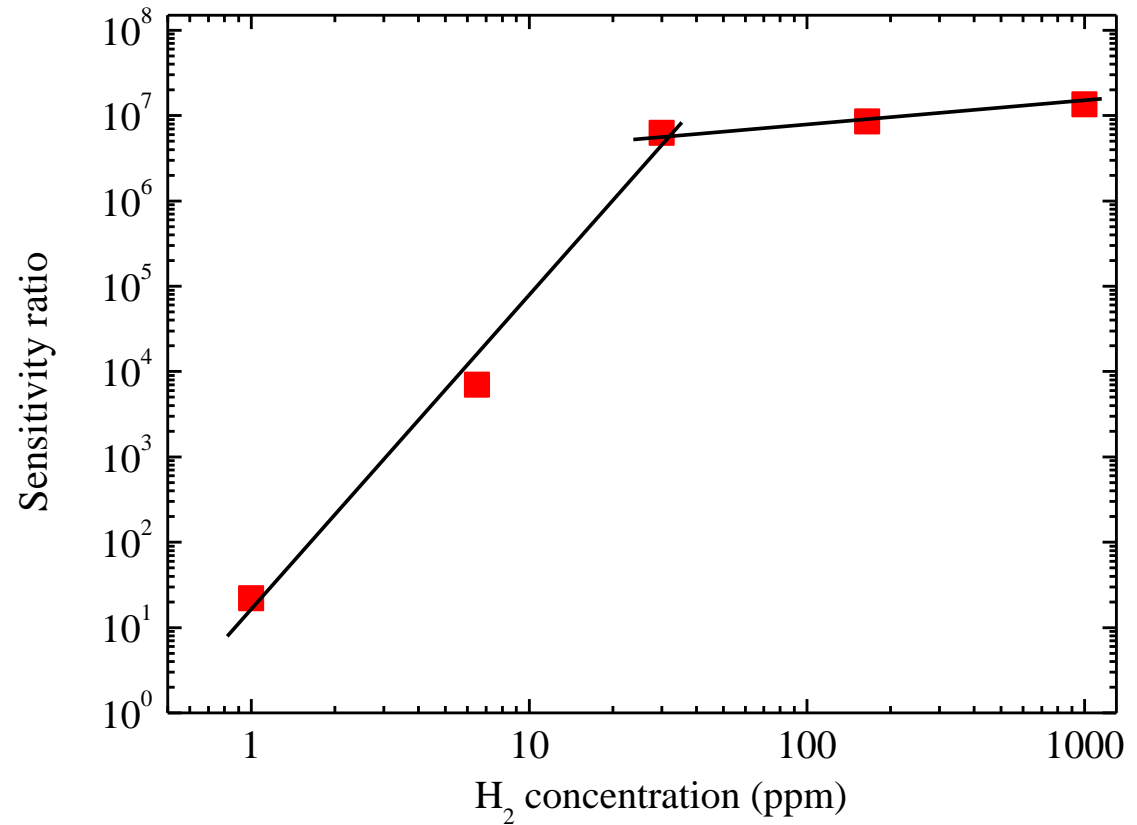
Semi logarithmic I-V and current-transient characteristics



Sensitivity



Sensitivity ratio:
 $S = (I_{H_2} - I_{air}) / I_{air}$



Conclusions

- **Pt NPs prepared by the reverse micelle technique.**
- **Formation of a Schottky barrier on n-type InP by the electrophoretic deposition of Pt NPs investigated.**
- **Good rectification ratios and barrier heights achieved.**
- **Excellent sensing properties to hydrogen presented.**

Acknowledgements



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