Composite nanomaterials for photocatalysis and solar cells

HEAD:

Prof. Magdalena Skompska*, PhD DSc

GROUP MEMBERS:

Iraida Demchenko, PhD DSc;
Agata Fedorczyk, PhD;
Maciej Kwiatkowski, PhD;
Kamila Zarębska, PhD
PhD student: Tomasz Łęcki
MSc student: Ewelina Kwiatkowska

RESEARCH PROFILE:

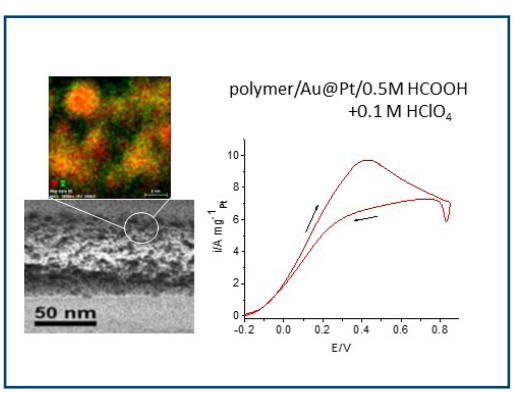
The scientific interest of the group is focused on elaboration of hybrid materials based on conducting polymers, metal nanoparticles, nanostructural semiconductors, and metal oxides, investigation of their electronic structure and applications in photocatalysis, electrocatalysis and solar cells.

Conducting polymers

- Electrosynthesis and characterization of conducting polymers: (poly(3-alkylthiophenes), poly(3,4-dialkoxythiophenes), polypyrrole derivatives, poly(N-vinylcarbazole), poly(1,8-diaminocarbazole), etc. Correlation of synthesis conditions with electrochemical properties of the polymer films in p- and n-doping ranges, polymer conductivity, morphology and molecular structure.

Nanostructural hybrid materials

- Elaboration of the composites: conducting polymer/semiconductor nanoparticles or fullerenes for application in the solar cells.
- Synthesis of metal nanoparticles (Au, Ag, Au@Pt) in the polymer matrices and investigation of their catalytic and electrocatalytic activity.
- Hydrothermal and electrochemical synthesis of ZnO nanorods and nanoplates on transparent conducting substrates (ITO, FTO). Sensitization of ZnO nanorods with CdS and CdSe nanocrystals for solar cells application.
- Elaboration of core-shell composites for photocatalysis

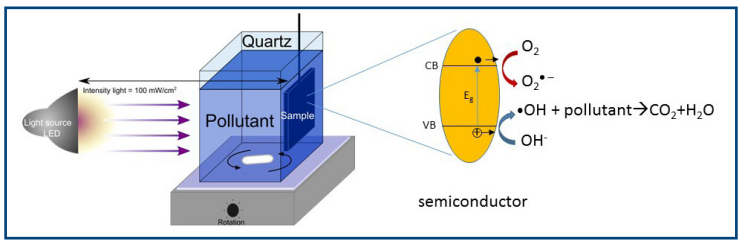


*e-mail: mskomps@chem.uw.edu.pl

(ZnO/TiO_2, TiO_2/CdS/polymer) and photoelectrocatalysis (ZnO/TiO_2 decorated with Au nanoparticles) in UV and visible light.

Employed techniques:

- "wet chemistry" methods for synthesis of nanomaterials: high pressure and microwave-assisted hydrothermal methods, sol-gel, etc.
- electrochemical methods (classical and electrochemical quartz microbalance – EQCM), spectroscopies (UV/vis and FTIR in transmission and reflection modes, Raman), X-ray spectroscopies, scaterring and corresponding computational modelling, XRD, microscopic techniques: AFM/STM, SEM, HR-TEM.



CURRENT RESEARCH ACTIVITIES:

1. Synthesis and characterization of new composite materials of the type: Fe_3O_4/TiO_2, $ZnO/BiVO_4$ for photocatalysis under visible light.
2. Preparation of visible-light driven photocatalysts by activation of the wide band-gap semiconductors ($SrTiO_3$, ZnO and $TiO_2/SrTiO_3$ composites) with plasmonic metal nanoparticles or by metal or non-metal doping.
3. Application of the elaborated materials in potential-assisted solar water splitting and photodegradation of organic water pollutants.
4. Organic/inorganic hybrid solar cells. The research group is involved in realization of the joint project "Efficient and light photo-rechargeable electric energy storage systems based on solar cell-lithium ion battery or solar cell-supercapacitor structures for special applications" within TECHMATSTRATEG (realized by consortium of 8 research groups).

SELECTED PUBLICATIONS:

1. I.N. Demchenko "Analytical Techniques for Characterization of Oxide-based Materials" Chap. 4 in "Oxide-based Materials and Structures: Fundamentals and Applications", Taylor & Francis Ltd, London, UK. ISBN 10 0367252392 (2020).
2. I.N. Demchenko, R. Ratajczak, Y. Melikhov et al., Valence band of ZnO:Yb probed by resonant photoemission spectroscopy, Materials science in semiconductor processing. 91 (2019) 306.
3. T. Łęcki, K. Zarębska, K. Sobczak, M. Skompska, Photocatalytic degradation of 4-chlorophenol with the use of $FTO/TiO_2/SrTiO_3$ composite prepared by microwave-assisted hydrothermal method, Appl. Surf. Sci. 470 (2019) 991.
4. K. Zarębska, T. Łęcki, M. Skompska, Synthesis of CdSe on ZnO nanorods by SILAR and electrochemical methods and comparison of photoelectrochemical properties of the FTO/ZnO/CdSe electrodes, J. Electroanal. Chem. 819 (2018) 459-468.
5. M. Kwiatkowski, R. Chassagnon, O. Heintz, N. Geoffroy, M. Skompska, I. Bezverkhyy, Improvement of Photocatalytic and Photoelectrochemical Activity of ZnO/TiO_2 Core/Shell System through Additional Calcination: Insight into the Mechanism, Applied Catalysis B: Environmental. 204 (2017) 200-208.
6. A. Fedorczyk , R. Pomorski, M. Chmielewski, J. Ratajczak, Z. Kaszkur, M. Skompska, Bimetallic Au@Pt nanoparticles dispersed in conducting polymer – A catalyst of enhanced activity towards formic acid electrooxidation, Electrochimica Acta. 246 (2017) 1029-1041.
7. A. Fedorczyk, J. Ratajczak, O. Kuzmych, M. Skompska, Kinetic studies of catalytic reduction of 4-nitrophenol with $NaBH_4$ by means of Au nanoparticles dispersed in a conducting polymer matrix, J. Solid State Electrochemistry. 19 (2015) 2849–2858.
8. M. Kwiatkowski, I. Bezverkhyy, M. Skompska, ZnO nanorods covered with TiO_2 layer: simple sol-gel preparation, optical, photocatalytic and photoelectrochemical properties, Journal of Materials Chemistry A. 24 (2015) 12748-12760.
9. M. Skompska, K. Zarębska, Electrodeposition of ZnO Nanorod Arrays on Transparent Conducting Substrates – a Review, Electrochimica Acta. 127 (2014) 467-488.
10. K. Zarębska, M. Kwiatkowski, M. Gniadek, M. Skompska, Electrodeposition of $Zn(OH)_2$, ZnO thin films and nanosheet-like Zn seed layers and influence of their morphology on growth of ZnO nanorods, Electrochimica Acta. 98 (2013) 255-262.