SOLAR ENERGY CONVERSION

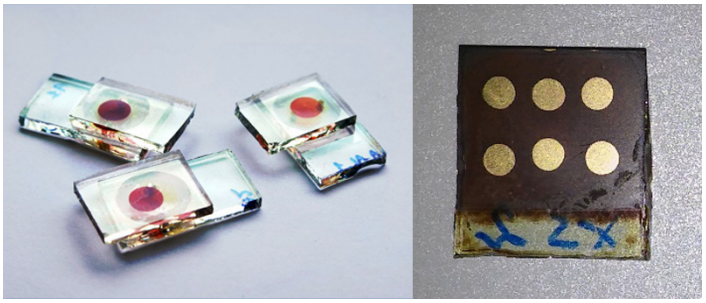
Faculty of Physics

RESEARCH AREA

Our research topics include dye-sensitized solar cells (DSSC), perovskite solar cells (PSC) and, recently, water splitting systems. In DSSC, our key interest is the interaction of organic dyes with the nanostructures of metal-oxide semiconductors. In PSC, the properties of novel organometal-halide materials and the processes at their interfaces with electron and hole transporting layers are investigated. We construct the prototype solar cells, measure their photovoltaic parameters, and use them as the samples for spectroscopic characterization, including time-resolved laser spectroscopy studies.

PREPARATION OF SOLAR CELLS

Our photo-electrodes are made by the preparation of metal-oxide nanostructure layers on conducting glass using doctor-blade, screen printing or spin coating techniques, followed by thermal annealing. The active material is introduced by sensitization in solution (DSSC) or spin-coating (PSC). Liquid electrolytes are used in the configuration with polymer sealing and conducting glass as counter electrode (DSSC), while solid-state charge transporting layers are formed by spin coating with further sputtering of gold as counter electrode (DSSC, PSC).



CHARACTERIZATION OF SOLAR CELLS

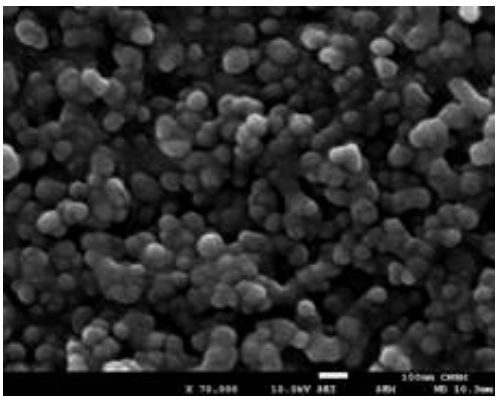
The prepared cells are characterized by basic photovoltaic techniques: current-voltage measurements (under simulated sunlight illumination) and incident photon to current efficiency (IPCE) spectra (Instytut Fotonowy, Poland). Charge dynamics on millisecond time scale is investigated by electrochemical impedance spectroscopy, photocurrent decay and photovoltage decay studies (Autolab potentiostat). The active materials are measured by stationary absorption (Jasco V-770, 190 - 2700 nm with 150 mm integrating sphere). Scanning electron microscopy (SEM) pictures are taken at Nanobiomedical Centre, UAM.

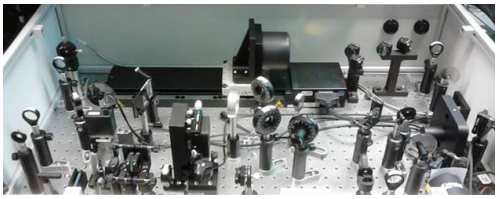
TIME-RESOLVED LASER SPECTROSCOPY

Our main specialization are the studies of the ultrafast and fast elementary charge separation processes taking place in the solar cells. After absorption of photon, an electron in active material is moved to its higher energetic state. For efficient photovoltaic operation, the electron must undergo a number of partial charge separation process, and many of them occur on the time scales from femtoseconds to microseconds, unavailable for typical opto-electrical techniques used in the photovoltaics. Therefore, we use laser pulses to track the dynamics of charge separation in complete solar cells as the samples, and correlate it with global photovoltaic parameters of the studied cells. The main tools employed are: femtosecond transient absorption (100 fs resolution, 3 ns time window, tunable excitation 240-2600 nm, probe detection in the UV-vis, near-infrared and mid-infrared ranges), picosecond time-resolved fluorescence (TSCPC setup, resolution of single ps) and nanosecond flash photolysis (time window up to milliseconds). These setups are located at Faculty of Physics and Center for Ultrafast Laser Spectroscopy, UAM.

RESULTS

We collaborate with several groups in Poland and abroad (Spain, Switzerland, Sweden). For more information, visit our webpage at: http://solencon.home.amu.edu.pl





SELECTED REPRESENTATIVE PAPERS IN RECENT YEARS

J. Sobuś, G. Burdziński, J. Karolczak, J. Idígoras, J. A. Anta, M. Ziółek, Comparison of TiO2 and ZnO Solar Cells Sensitized with an Indoline Dye: Time-Resolved Laser Spectroscopy Studies of Partial Charge Separation Processes, *Langmuir*, **30** (2014) 2505.

J. Idígoras, G. Burdziński, J. Karolczak, J. Kubicki, G. Oskam, J. A. Anta, M. Ziółek, The Impact of the Electrical Nature of the Metal Oxide on the Performance in Dye-Sensitized Solar Cells: New Look at Old Paradigms, *J. Phys. Chem. C*, **119** (2015) 3931.

K. Pydzińska, J. Karolczak, I. Kosta, R. Tena-Zaera, A. Todinova, J. Idígoras, J. A. Anta, M. Ziółek, Determination of interfacial charge transfer rate constants in perovskite solar cells, *ChemSusChem* **9** (2016) , 1647.

J. Sobuś, B. Gierczyk, G. Burdziński, M. Jancelewicz, E. Polanski, A. Hagfeldt, M. Ziółek, Factors affecting the performance of champion silyl-anchor carbazole dye revealed in the femtosecond to second studies of complete ADEKA-1 sensitized solar cells, *Chem. Eur. J.* **22** (2016) 15807.