Katedra Materiałów Inżynierskich i Biomedycznych

Investigations on the dye-sensitized solar cells (DSSC) with hybrid nanostructural photoanodes

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The authors focused on the manufactures and research of dye photovoltaic cells (DSSC) with a nano-structured photoanodes consisting of ZnO nanowires and TiO_2 nanoparticles. The purpose of the work include the photoanodes preparation from nanowires and nanoparticles allowing for obtain high electron transport with low electron recombination.Anode layers have been deposited from the paste containing nanostructures leading method of screen printing techniques Research has shown that nanomaterial produced by electrospinning method has a large surface area that provides much better physical properties, compared to the properties of conventional materials making them suitable for use in self-cleaning surfaces, dye photovoltaic cellThe results confirms the possibility of using obtain material as photoanode with expanded surface area and satisfactory optical properties. In addition, the obtained efficiencies comparable to receive in other scientific centres, it allows to conclude that the combination of nanoparticles and nanowires is an interesting direction for the development of DSSC.

The basic task in the research was to deposited photoanode with architecture: Glass/(FTO conducted layer)/nanostructural TiO_2/ZnO hybrid layer/ N-719 dye, using screen printing method provided to uniformity structure of the layer and repeatability of the production process. Photoanodes has been deposited on glass substrates with FTO coating (resistivity 10 [Ω/sq]. On the FTO conductive surface paste containing TiO_2 nanoparticles and ZnO nanowires was applied by screen printing method. The composition of screen printable TiO_2/ZnO NP/NW past has been prepared on the basis of data from literature analysis and shown in Table 1. .

In order to determine the structure and morphology of the surface of deposition layers, the structural investigation using the Zeiss Supra 35 scanning electron microscope were carried. Observations of topography and surface morphology of the screen printed layer were carried out in a scanning electron microscope Supra-35 from Zeiss. Magnification ranged from 20.00kx-200.00kx, accelerating voltage 2-3kv, work distance 3-3.5 and InLens mode selected for flat and nanometric samples were used. Qualitative studies of chemical composition were also performed using the Energy Dispersive Spectrometer (EDS). Investigations of optical properties of photoanodes were conducted using the Thermo Scientific Evolution 220 spectrophotometer with a xenon lamp with a wavelength range from 200 to 1200 nm. Absorbance was measured before and after dye deposition on the FTO/TiO_2, layers.-V characteristics of DSSC were measured using PV Test Solutions Tadeusz Zdanowicz Solar Cell I-V Tracer System and Keithley 2410 source meter under Standard Test Conditions (AM 1.5, 100 W/m^2).

Table 1. Composition of screen printable paste.

Component	Semiconductor 1	Semiconductor 2	Binder	Rheological agent	Dispersant	Solvent/binder
Material	TiO_2 NP (g)	ZnO NW (g)	Polyethylene glycol 20000 (g)	Ethylcellulose (g)	Terpineol (ml)	Ethanol (ml)
	0.6	0.3	0.3	0.1	0.5	4.0

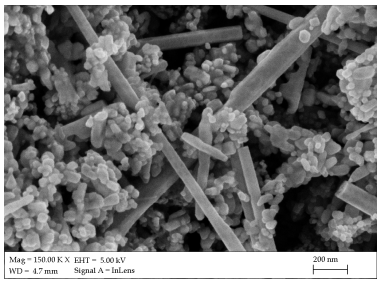

Fig. 1. SEM image of the TiO_2/ZnO NP/NW nanocomposite layer deposited by the screen printing method.

Table 2. Electrical properties of dye photovoltaic cells with TiO_2/ZnO (NP/NW) photoanode

Electrical properties	TiO_2/ZnO (NP/NW) photoanode DSSC	
	1	2
I_{sc} [mA]	3.542	3.569
V_{oc} [mV]	584.074	614.970
I_M [mA]	2.605	2.692
U_M [mV]	368.968	395.336
P_M [mW]	961.077	1.064
FF	0.46	0.48
E_{ff} [%]	2.27	2.53

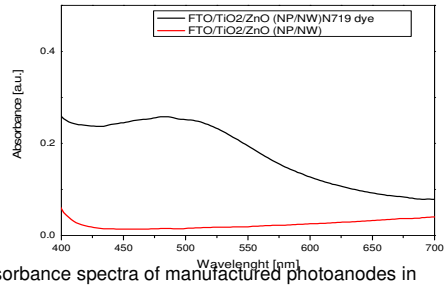

Fig. 2. Absorbance spectra of manufactured photoanodes in wavelength 400-700 nm,.

Research results indicate that the morphology of TiO_2/ZnO (NP/NW) significantly affects the photovoltasic properties obtained by DSSC. The applied techniques allow for both obtaining nanowires that can be successfully used in DSSC photoanode structures as well as effective rapid and dimensionally repeatable production of photoanode layers in terms of properties. The obtained results of efficiency and their analysis suggest, however, occurrence of irregularities during the process of producing photoanodes mainly associated with insufficient distribution of the components of the layer, especially on the surface of the layer. This is indicated by the results not only of the I-V characteristics tests, but also absorption measurements. Also a comparison of the results obtained with those obtained by the authors in previous papers [63] indicates the possibility of obtaining higher efficiency in the similar structure produced by the same methods. The achieved efficiency, however, confirms the possibility of further development of this type of structures, which is contribution to further research of photoanodes.

The research presented in this article was financed by the National Science Centre, Poland based on the decision number 2016/23/B/ST8/02045.