Electrochemical properties of electrophoretically deposited ZnO thin films

Jovita Grigonytė, Simona Ostachavičiūtė, Dovilė Sinkevičiūtė, Nerita Žmuidzinavičienė, Agnė Šulčiūtė*
Department of Physical and Inorganic Chemistry, Kaunas University of Technology, Lithuania
agne.sulciute@ktu.lt

Introduction

ZnO is a multifunctional material due to its unique physical and chemical properties: high chemical stability, electrochemical coupling effect, wide absorption range, paramagnetic nature and high photostability [1-2]. However, one of the most important properties of ZnO is - photocatalytic activity, which allows it to decompose pollutants and water into hydrogen and oxygen gases. Therefore, the aim of this work is to investigate photocatalytic properties of ZnO thin films electrophoretically deposited on FTO glass.

ZnO production and films formation

Firstly, ZnO was produced by thermal synthesis from zinc acetate at 400 °C for 1 hour (Figure 1 a-b).
Then ZnO was electrochemically deposited on electrically conductive FTO glass. The constant potential was maintained from 15 V to 30 V with the step of 5 V, and the deposition time was from 5 min up to 30 min (step - 5 min) during electrophoresis.

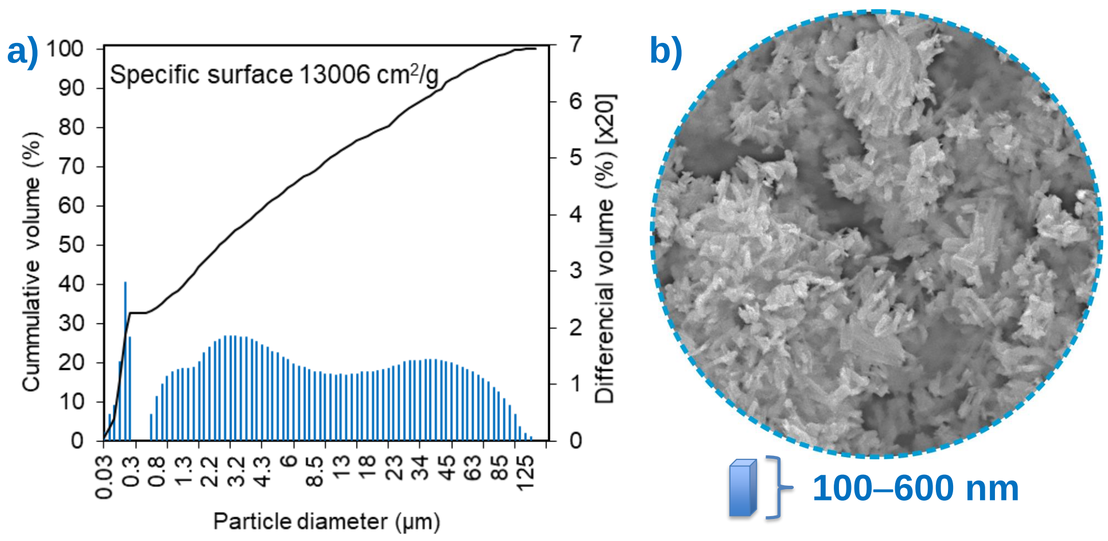

Fig. 1. Synthesized ZnO particle size distribution (a) and SEM micrograph at × 10000 magnification (b)

Methods

Photoelectrochemical activity of prepared electrodes was investigated in a quartz cell in phosphate-buffer solution (pH 7). General Electric F8W/BLB lamp (λ_{max} = 366 nm, power density 1.8 mA·cm^{-2} , 2 cm placed from working electrode) was used as UV irradiation source.

IPCE value of a photoelectrode was calculated using the following equation [3]:

$$IPCE\,(\%) = 100\frac{1240 \cdot j_{ph}}{\lambda \cdot \mathrm{P}};$$

where j_{ph} is photocurrent density in mA · cm^{-2}, λ (366 nm) is a wavelength of incident light in nanometers, and P is incident light intensity in mA·cm^{-2} , here 1.8.

Applied bias photon-to-current efficiency (*ABPE*) calculations were used to characterize photo-response efficiency of photoelectrode material under applied voltage according to the following equation [4]:

$$ABPE\,(\%) = 100\frac{|j_{ph}| \cdot \left(1.23 - \left|\mathrm{V_{appl}}\right|\right)}{I_0};$$

Here, j_{ph} is photocurrent density (mA · cm^{-2}) and *I0* is input intensity of incident light falling on a surface of photoelectrode (1.8 mA·cm^{-2}).
V_{app} is applied potential, which is calculated according to the equation:

$V_{appl} = V_{mea} - V_{oc}$

Here, V_{mea} is working electrode potential at which photocurrent was measured under illumination and V_{oc} is working electrode potential at open circuit condition under similar conditions.

Results

The most stable electrodeposited ZnO thin films on FTO glass surface, with the highest photoactivity, was synthesized from ZnO formed by thermal synthesis at 400 °C. The voltage of electrophoresis was 25 V and duration - 10 minutes. The highest photoelectrochemical and photoconversion efficiency values were 0.55 % and 0.2 % (Fig. 2), respectively.

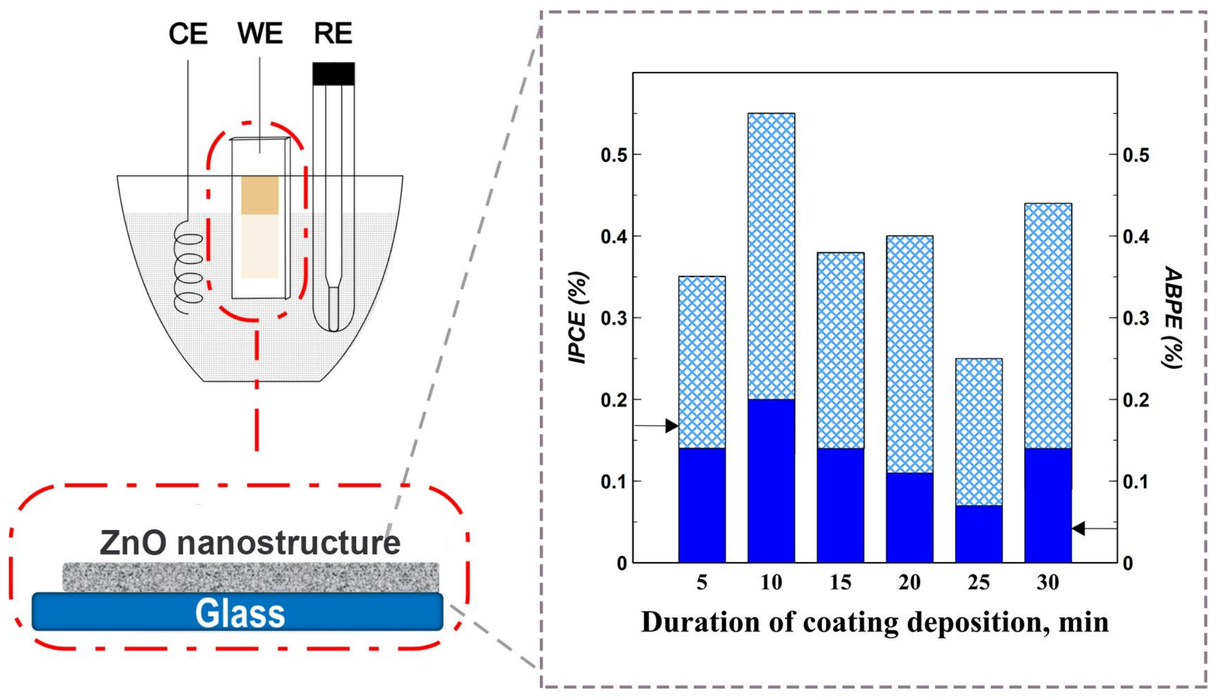

Fig. 2. The incident photon-to-current efficiency (IPCE) and applied bias photon- to-current conversion efficiency (ABPE) values for ZnO thin films in the phosphate-buffer solution (pH 7), E = 0.6 V

References

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