11th International Conference
on Advanced Materials

Rio de Janeiro Brazil
September 20 - 25

ICAM2009

Porous S-doped ZnO electrode for application in solar energy conversion

Everson T. S. G. Silva*, Gabriela Z. Bosshard, Fernando A. Sigoli, Claudia Longo

Institute of Chemistry, State University of Campinas – UNICAMP, Campinas, SP, Brazil
* Corresponding author: esilva@iqm.unicamp.br

Abstract – Crystalline S-doped ZnO particles, obtained from thermal treatment of ZnS at 640 °C for 20 min, exhibited absorption of visible light (maximum at 430 nm) and band gap energy of 2.9 eV. Investigation of the electrochemical properties of S-ZnO porous film deposited on transparent electrode revealed a negative open circuit potential and a positive photocurrent, a typical behavior of a n-type semiconductor electrode. The observed band gap value and the high photocurrent indicate that the porous S-ZnO electrode is a promising material for energy conversion.

Solar energy is abundant, clean, safe, and allows energy generation in remote areas. Solar energy conversion and storage can be achieved by photo-electrochemical processes using semiconductor oxides. When illuminated, the semiconductor collects photons with energy that exceeds the energy gap between the valence and the conduction bands (E_{BG}) and it promotes the charge separation of electron/hole pairs [1]. For TiO_2 and ZnO, the photo activity is observed only for UV irradiation, since E_{BG}~3.1-3.2 eV. The E_{BG} of these semiconductors can be narrowed by doping, resulting in collection of visible light and higher efficiency for solar energy conversion. This contribution reports on the investigation of morphological and electrochemical properties of porous S-doped ZnO (S-ZnO), obtained from thermal treatment of ZnS.

ZnS nanoparticles were synthesized by precipitation from aqueous solutions of $Zn(NO_3)_2$ and thioacetamide. After rinsing with water and drying, the ZnS particles were heated at 640 °C for 20 min, resulting in yellow particles of S-ZnO [2, 3]. A porous film of S-ZnO was deposited on transparent electrodes (glass with a conductive film of F-SnO_2, glass-FTO) from an aqueous suspension containing polyethylene glycol followed by heating at 450 °C for 30 min.

The crystalline hexagonal phase characteristic of ZnO was identified from X-ray diffraction analysis. From diffuse reflectance and absorbance of UV-visible spectroscopy, the E_{BG} was estimated as 3.3 eV for ZnS and 2.9 eV for S-ZnO (Figure 1). The topography of the film was examined by scanning electron microscopy and a porous and uniform film was observed. The electrochemical properties of S-ZnO films were investigated in aqueous Na_2SO_4 solution in the dark and under irradiation from a solar simulator. In the dark, cyclic voltammetry of the glass-FTO|S-ZnO electrode (Figure 2) revealed a small capacitive current, and the H_2 and O_2 evolution reactions were observed at -0.2 and +1.2 V (vs. Ag/AgCl). Under polychromatic irradiation, the negative open circuit potential, -0.28 V, can be attributed to electron injection into the conduction band due to charge separation, as well as the positive photocurrent, indicated the behavior of an n-type semiconductor electrode. Also, the larger area beneath the voltammogram suggests that the electroactive area of the S-ZnO film is probably higher under irradiation. The photocatalytic activity of the electrode for phenol degradation is under investigation. The narrow band gap energy, 2.9 eV (which corresponds to 430 nm) and the high photocurrent exhibited by the porous S-ZnO electrode under polychromatic irradiation indicate this is a promising material for solar energy conversion. *CAPES, CNPq, INOMAT, FAPESP.*

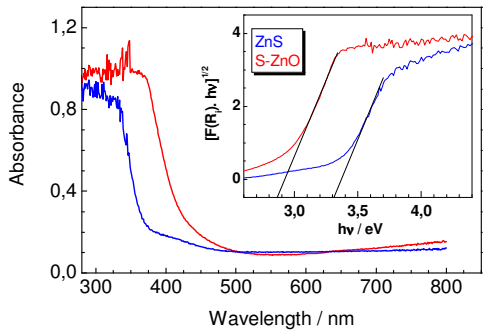

Figure 1: UV-Vis absorption spectra for ZnS and S-ZnO particles. Insert: estimative of band gap energy.

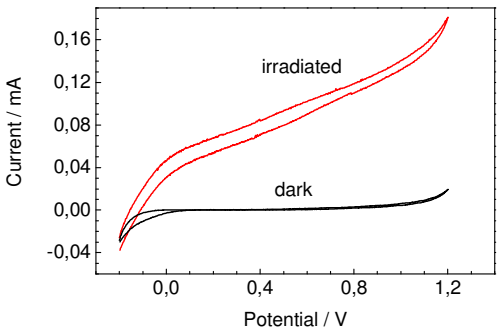

Figure 2: Cyclic voltammogram for glass-FTO|S-ZnO electrode in aqueous Na_2SO_4 solution in the dark and under polychromatic irradiation.

References

[1] C. Longo, M.-A. De Paoli, J. Braz. Chem. Soc. 14 (2003) 889–901.
[2] G.A. Martínez-Castañón; J.R. Martínez-Mendoza; F. Ruiz; J. González-Hernández. Inorg. Chem. Commun. 10 (2007) 531–534.
[3] S. Kar; P. Dutta; T.Pal; S. Ghosh. Chem. Phys. Lett.. 473 (2009) 102–107.