Chemical Physics Letters 550 (2012) 125–129

Contents lists available at SciVerse ScienceDirect

Chemical Physics Letters

journal homepage: www.elsevier.com/locate/cplett

Nanofibrous-like ZnO layers deposited by magnetron sputtering and their integration in dye-sensitized solar cells

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ARTICLE INFO

Article history:
Received 24 May 2012
In final form 31 August 2012
Available online 8 September 2012

ABSTRACT

We present a cost-effective and fast fabrication of nanofibrous ZnO layers by the magnetron sputtering method. The as-prepared layers were characterized by scanning electron microscopy, energy dispersive X-ray spectrometry, X-ray diffraction, Raman spectroscopy, photoluminescence, and optical studies. The nanofibrous layers show good structural properties offering an excellent nanomaterial for dye-sensitized solar cells (DSSCs) application. Their integration for solar energy conversion is studied by photocurrent–voltage (*J*–*V*) measurement, impedance spectroscopy and the developed DSSC structure exhibits promising performances. This Letter provides a technological route to the facile growth of zinc oxide nanofibrous layers through magnetron sputtering, which have several potential applications.

1. Introduction

Recently, the study of zinc oxide-based nanoscale structures has attracted considerable attention due to their unique properties, their very large surface-to-volume ratios and diverse applications in nanoelectronic devices [1–4]. Zinc oxide nanowires, nanorods, tetrapods clearly demonstrate utility of such nanomaterial in light emitting diodes, sensor and ultraviolet (UV) photodetectors [4]. Among different nanostructures, nanofibrous membranes/layers have attracted increasing attention over the last years due to their inherent large specific surface area, which facilitate the adsorption/desorption processes [5–7]. Usually, the properties of nanostructured ZnO semiconductors strongly depend on the surface of the nanomaterial [8]. In this context, it is relevant to Letter any kind of approach to improve devices performances. Typically, the nanomaterials based on ZnO can be fabricated by various growth techniques, including electrodeposition [2,8–11], hydrothermal synthesis [1], vapor–liquid–solid (VLS), vapor–solid (VS) [12] processes, metal–organic chemical vapor deposition (MOCVD) [13], chemical vapor deposition [14], etc. The magnetron sputtering technique has been widely used to synthesize ZnO materials [1].

Dye-sensitized solar cells (DSSCs) as a new generation of commercial solar cells have attracted considerable attention of researchers because they are characterized by low cost, promising efficiency, and possibilities for environmental protection [15]. A dye-sensitized solar cell consists of a photoanode, electrolyte, and counter electrode. In this context the photoanode is the critical component of the DSSC, which is generally a dye-sensitized porous oxide (TiO_2 or ZnO) thick film that adheres to Fluor-doped tin oxide (FTO) glass substrate [5,6,15,16]. However, for future applications, DSSCs should be based on inexpensive transparent conductive materials and achieve high light harvesting and efficient charge collection [17]. Researchers have studied different approaches to synthesize and use a cost-effective nanomaterial. Low-cost nanomaterial layers based dye-sensitized solar cells, which emerged in recent years, have the potential to meet these requirements. Zinc oxide (ZnO) is a key functional material exhibiting near-ultraviolet emission, semiconducting, magnetic, and piezoelectric properties. Thus, ZnO is one of the metal oxides with wide-band gap that is of great interest for versatile applications, especially in DSSC [9–11,18].

Herein, we present the fabrication of ZnO material with nanofibrous surface morphology by a magnetron sputtering technique. Scanning electron microscopy (SEM), energy dispersive X-ray analysis (EDX), X-ray diffraction (XRD), photoluminescence (PL) and Raman spectroscopy studies were carried out to characterize the as-prepared samples. We further demonstrate the solar conversion ability of ZnO nanofibrous membranes integrated in DSSC. The developed solar cell exhibits promising performances. More generally, the present Letter provides a simple strategy to develop ZnO nanofibrous layers, which are promising for various device applications.

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http://dx.doi.org/10.1016/j.cplett.2012.08.071