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半導體奈米粒子用於高分子/無機奈米混成太陽能電池的研究

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Synthesis of TiO_2 Nanorods and Fabrication of TiO_2 Nanorods/MEH-PPV Hybrid Material for photovoltaic Applications

Tsung-Wei Tseng and Wei-Fang Su

Department of Materials Science and Engineering, National Taiwan University, Taipei, Taiwan, R.O.C.

Abstract

The 3nm x 30nm TiO_2 nanorods were synthesized by modified sol-gel method under low temperature (90°C) and are in anatase structure. We have investigated the morphology, crystallinity and optical properties of TiO_2 nanorods synthesized. Furthermore, the TiO_2 nanorods/MEH-PPV hybrid material is fabricated for photovoltaic applications via spin coating process. The large interfacial area between the two materials due to high surface to volume ratio of rod shape nanocrystals ensures a more efficient charge separation. The material composed of 1-D nanostructure could potentially improve charge transport in photoactive materials.

Introduction

One dimensional semiconductor nanostructures are of great interest because they offer a wide range of size and shape-tunable electrical and optical properties and are expected to play an important role in the fabrication of electronic devices[1, 2]. Recently, it is demonstrated that semiconductor nanorods can be used to fabricate efficient hybrid solar cells with conjugated polymers. 1-D nanostructures provide a directed path for electron transport. Thus, electrons could be transported directly through the thin film device efficiently. For devices made of spherical nanocrystals, lower photocatalytic quantum yields are observed when they are smaller than a certain dimension due to the increased electron-hole recombination probability at trapping sites exist in grain boundaries at the contacts between nanosize particles. The use of 1-D nanostructures instead of nanoparticles is expected to result in a great improvement for rapid electron transfer and efficiency in electronic devices[3]. Hybird materials consisit of nanoparticles with conjugated polymer were widely investigated in the field of photovoltaic applications[4]. However, the investigations of photoactive material composed of 1-D nanostructures are much less. In this work, TiO_2 nanorods were synthesized and characterized. And thin films consist of TiO_2 nanorods and MEH-PPV is fabricated for further study of photovoltaic applications.

Results and Discussion

Synthesis of TiO_2 Nanorods

Oleic acid end-capped TiO_2 nanorods was synthesized by hydrolysis of titanium tetraisopropoxide[2].120 g of oleic acid was dried at 120 °C for 1 hour under vigorous stirring in a 250 mL three-neck flask, after which it was cooled to 90°C. 17mmol of titanium tetraisopropoxide was added into the system. After 5min, 34mmol of trimethylamino-N-oxide dehydrate in 17ml H_2O was injected. The presence of trimethylamino-N-oxide dehydrate is used as catalyst for polycondensation. The reaction is taken 6-12 hours for further hydrolysis and crystallization.

Morphology, crystallinity and optical properties of TiO_2 nanorods

The structure characterization of TiO_2 nanorods was performed by powder X-ray diffraction. Rods diameter calculated with the Scherrer formula from the (101) peak of XRD pattern is 4.5nm.The length TiO_2 nanorods estimated by of Scherrer formula from the (004) peak is 22 nm (Figure 1). The morphology of the nanorods was obtained by transmission electron microscopy. A rodlike morphology with a diameter of 3-4 nm and length up to 40 nm in length is observed (Figure 2). The UV-vis absorption spectrum of rod-shape TiO_2 nanocrystals is shown in Figure 3. A strong increase in absorption appears at about 350nm caused by excitations of electrons from the valence band to the conduction band of titania. Excitation of the sample at 270 nm results in a broad emission peak centered around 350 nm and several weaker bands were observed.

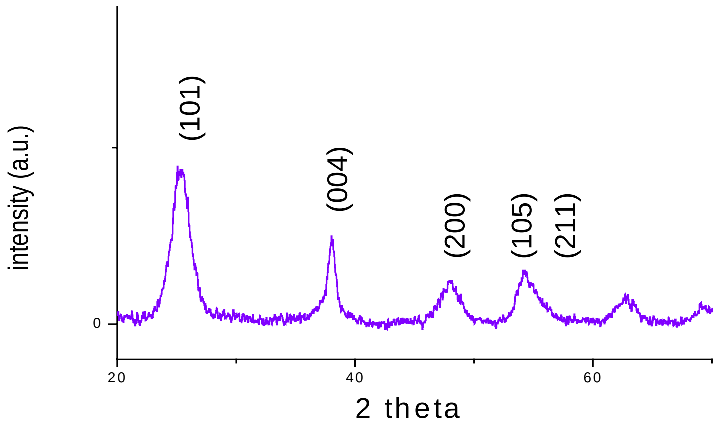

Figure 1 XRD pattern of rod-shape TiO_2 nanocrystals prepared.

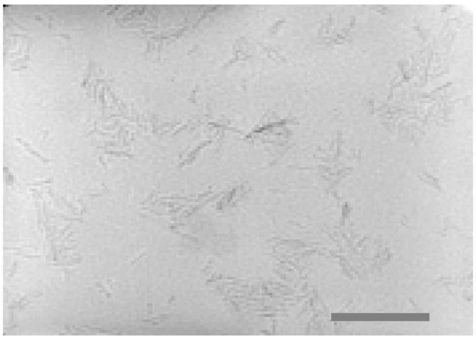

Figure 2 TEM image of rod-shape TiO_2 nanocrystals prepared (scale bar: 100nm).

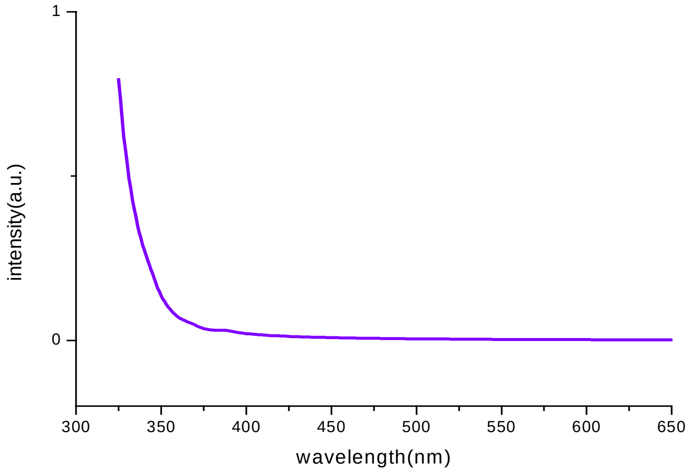

Figure 3 Absorption spectra of rod-shape TiO_2 nanocrystals (0.45mg in 1ml $CHCl_3$).

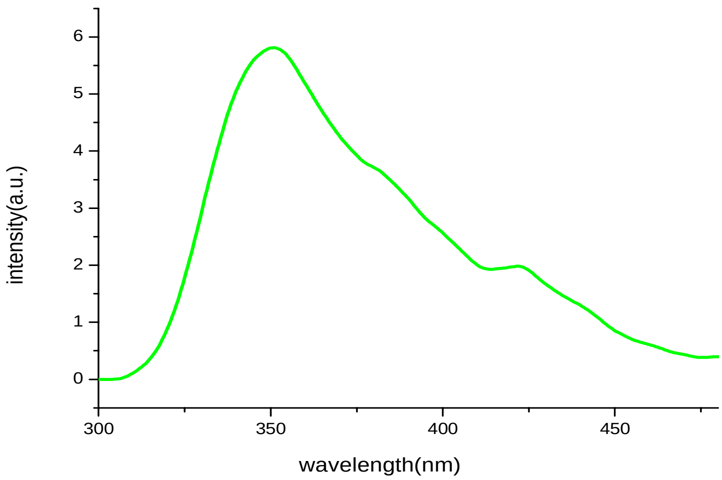

Figure 4 Photoluminescence emission spectra of rod-shape TiO_2 nanocrystals

TiO_2 Nanorods/MEH-PPV Hybrid Material

Thin films were fabricated by spin coating chloroform solutions onto ITO-covered glass slides. Large interfacial area between the two materials due to high surface to volume ratio of rod shape nanocrystals ensures a more efficient charge separation.

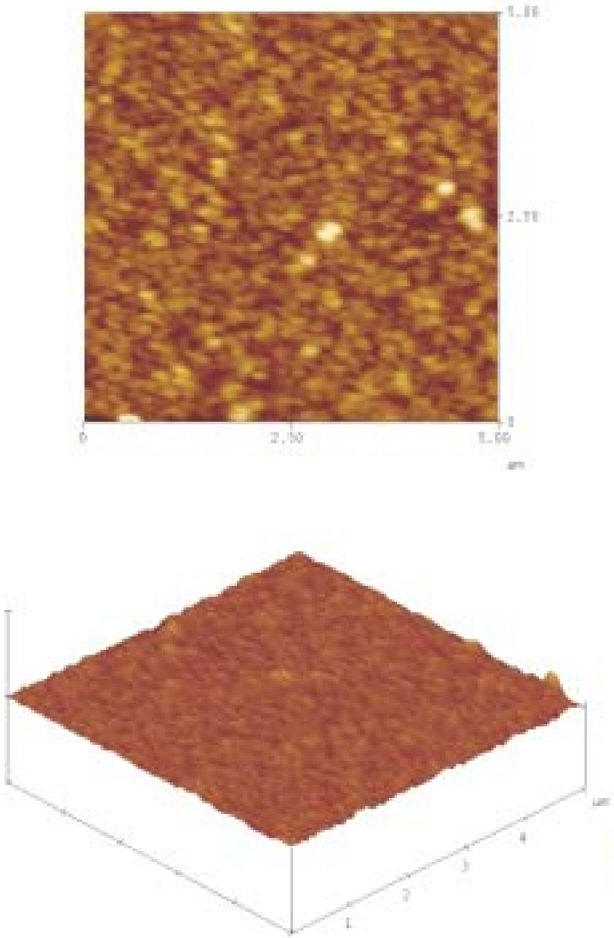

Figure 5 AFM images of hybrid material composed of MEH-PPV mixed with oleic acid capped TiO_2 nanorods (75wt% TiO2, 25wt% MEH-PPV).

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