RSC Advances

PAPER

View Article Online
View Journal | View Issue

Cite this: *RSC Adv.*, 2018, **8**, 11330

Enhanced photoconductivity in CdS/betanin composite nanostructures†

N. Susha,[a] K. Nandakumar [b] and Swapna S. Nair *[a]

Received 7th December 2017
Accepted 7th March 2018

DOI: 10.1039/c7ra13116j

rsc.li/rsc-advances

Development of novel materials for thin film solar cells are gaining significant attention due to their tunable wide bandgap and extensive application potential in flexible energy harvesters. CdS is a known window material for thin film solar cells. Tuning of the photoconductivity of CdS by doping, substitution and grain size tailoring is widely attempted by researchers. Inorganic core/shell structures like CdS/CdSe, CdS/ZnS *etc.* are other possible candidates with band gap tailorability. However, such attempts are rare in tailoring the photoconductivity by providing an organic shell over the inorganic core. Here the authors synthesised CdS/betanin core/shell structures using wet chemical routes. Spectroscopic studies show that the composite structure is core/shell like, with CdS as the core and betanin (a natural dye), as the outer shell with an average core particle size of 10 nm. The absorption spectra of the composite system show the signature of an additional band in the lower wavelength region and it is redshifted with increase in betanin percentage. The intermediate band observed in the energy of ~1.75 eV, helps CdS to enhance the rate of absorption. Simultaneous absorbance of lower and higher energy photons from the solar radiation can increase the efficiency of CdS based solar cells. A huge enhancement in conductivity is observed in CdS/betanin composites on illumination with white light due to the transfer of photogenerated electrons from the conduction band of betanin dye to the conduction band of CdS.

Introduction

Semiconductors, especially silicon (Si) based electronic devices, inexorably paved the way for the modern technology of computation and electronics. The innovation and tailoring of "nano" introduced wide varieties of material choices for the device fabrication other than silicon, which has had a dominance in the semiconductor industry for the last 50 years. Exploring an efficient low-cost alternative for Si, to meet its marketing demands, is still a challenge for the researchers working in the field of electronic device fabrication. Alterations in electronic gadgets such as scaling down, have extended the life span, while higher efficiency empowered their advancement in an unlimited number of applications and hence researchers are so energized in embracing wide band gap materials in electronic device fabrication.[1,2] Wide bandgap semiconductors (materials which have band gap relatively greater than conventional silicon) like silicon carbide (SiC, band gap 3.3 eV) and gallium nitride (GaN, band gap 3.4 eV) thus emerged as the front running solutions for the power and heat issues of silicon (band gap 1.1 eV). Comparing to Si, SiC is the most maturely developed wide band gap material which has high-temperature/voltage stability with 20% higher efficiency.[3,4] But presently its production is much more expensive than silicon. GaN is one among the widely explored cost effective alternative that offers similar performance of SiC. However, the problems associated with the synthesis of GaN demands alternative material search in this regard.

It is reported[5] that tailoring the size, structure, morphology and chemical composition of nanomaterials can deliberately tune their properties and its integration leads to nanoscale device fabrication. So, the migration to novel materials other than conventional SiC and GaN can pave way to enhanced efficiency of electronic devices.

Quantum dots, the ultrafine nanoparticles (size below 10 nm), offer higher band gap than their bulk cousins due to the size dependent quantum confinement effects. This property of quantum dot helps them to harvest the hot electrons from the material with high energy photons and generating multiple charge carriers which offers new ways to attain greater efficiency in the next generation solar cells.[6] For the last few years, II–VI group semiconductors attracted researchers owing to its wide band gap, availability, easy synthesis and band gap tunability.[7–9] Among them, CdS is one of the most prominent candidate which has potential application in the field of optoelectronics. Tailoring of band gap of CdS is possible by varying the experimental conditions such as concentration, pH, stoichiometry, temperature *etc.* Experimentalists used organic as well as

[a]*Dept. of Physics, Central University of Kerala, Kasaragod, India – 671314*

[b]*International and Inter University Centre for Nanoscience and Nanotechnology, Mahatma Gandhi University, Kottayam, India – 686 560. E-mail: swapna@cukerala.ac.in*

† Electronic supplementary information (ESI) available. See DOI: 10.1039/c7ra13116j