Fabrication of hybrid TiO_2-CdSe nano "matchstick" photovoltaic devices

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Introduction

Current silicon based solar cells are limited, not due to advances in technology, but due to the physics of the device itself. Recombination of electron-hole pairs created from incident photons inside the silicon layer reduces device efficiency.

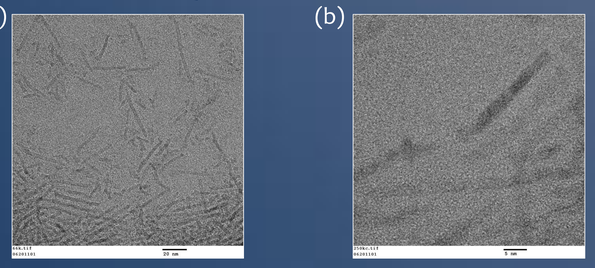
Cadmium selenide (CdSe) nanocrystals in photovoltaic devices offer many advantages over current silicon based solar cells. CdSe nanocrystals are facile and cost efficient to produce . More importantly, CdSe has tunable band gap capabilities whereas the band gap of silicon is fixed due to its physical characteristics. However, a photovoltaic device constructed solely of CdSe nanocrystals possesses the same disadvantages as silicon devices. A lack of a direct path for electrons to flow drastically reduces efficiency. To solve this problem while capitalizing on the advantages of CdSe nanocrystals, our device was constructed using CdSe nanocrystals preferentially grown onto the tips of titanium dioxide (TiO_2) nanorods. This produced "matchstick" nanostructures that could be aligned to a glass/ITO substrate using electrophoretic deposition (EPD). The device will be capped with an aluminum contact.

TiO_2 nanorod synthesis

Titanium dioxide nanorods were synthesized [1]:

- 9.6ml oleic acid + 5.0ml octadecene under vacuum using a Schlenk line at 110°C.
- Injected 0.6ml titanium isopropoxide into solution, then temperature increased to 270°C.
- Injected 2.0ml oleylamine.

(a) (b)

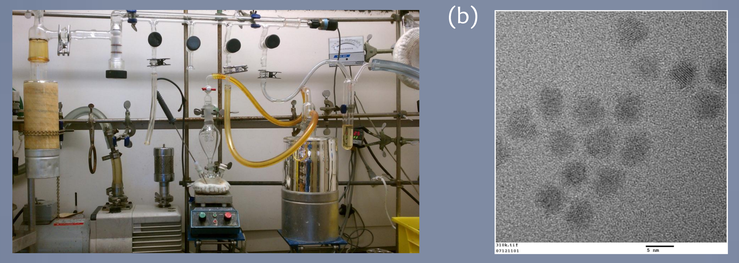


(a)Low resolution transmission electron microscopy (TEM) of TiO_2 nanorods. (b) High resolution TEM of TiO_2 nanorods.

[1] Bo Ye, et al. *Current Nanoscience*,**2010**,*Vol.* 6 (3), 262-268.

Preferential growth TiO_2-CdSe nano-matchstick structures

(a) (b)



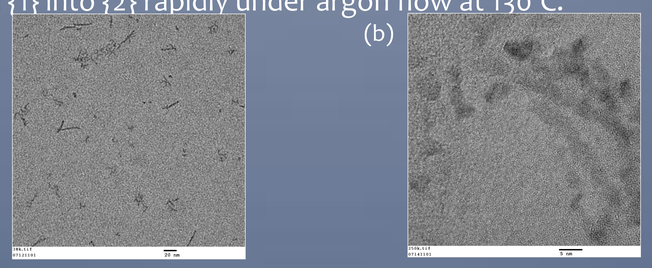
(a) Typical synthesis setup using Schlenk line. (b)High resolution TEM of CdSe nanocrystals.

Preferential growth was performed following a modified version [2]:

Method 1:

- {1} 1.5ml oleic acid + 2.0ml diphenyl ether + 533mg cadmium acetate at 100°C.
- {2} 10ml diphenyl ether under vacuum using a Schlenk line at 100°C.
- 0.25ml TiO_2 nanorods + 2.0ml hexanes injected into {2}
- 1.0ml TBP:Selenium injected into {1}.
- Injected {1} into {2} rapidly under argon flow at 130°C.

(a) (b)

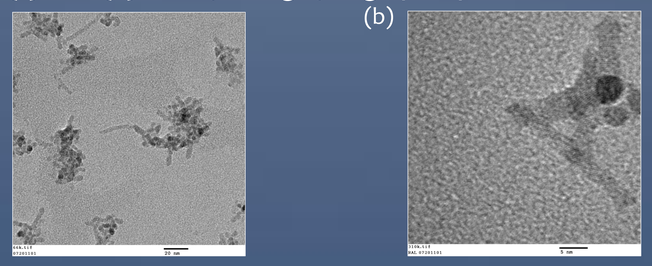


(a)Low resolution TEM of TiO_2-CdSe nano-matchsticks. (b) High resolution TEM of TiO_2-CdSe nano-matchsticks.

Method 2:

- {1} 2.4ml oleic acid + 2.0ml octadecene + 258mg cadmium oxide at 100°C.
- {2} 10ml octadecene under vacuum using a Schlenk line at 100°C.
- 0.25ml Tio_2 nanorods + 2.0ml hexanes injected into {2}.
- 7.5ml TBP:Selenium injected into {1}.
- Injected {1} into {2} slowly using syringe pump at 200°C.

(a) (b)



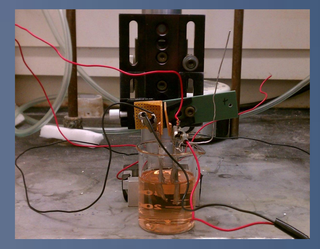
(a)Low resolution TEM of TiO_2-CdSe nano-matchsticks. (b) High resolution TEM of TiO_2-CdSe nano-matchsticks.

[2] Stefan Kudera, et al. *Nano Letters*, **2005**, *Vol. 5 (3)*, 445-449.

Electrophoretic deposition (EPD)

Colloidal particles suspended in a liquid are attracted to an electrode under the influence of an electric field. Used to apply materials to an electrically conductive substrate.

(a)

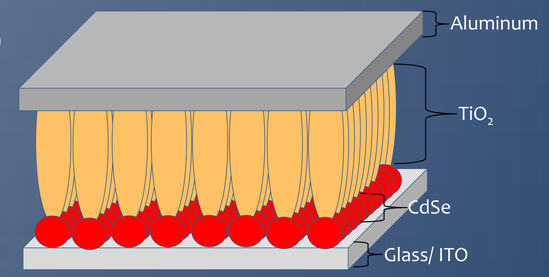


(a) Typical experimental setup using EPD.

Future work

- ❑ Experiment with temperature and injection rate to improve preferential growth.
- ❑ Perform EPD on sample to test alignment of nanostructures to glass/ ITO substrate.
- ❑ Construct a device, test, and plot current-voltage data to find overall efficiency.
- ❑ Conduct tests using STEM/EBIC on the device.

(a)



(a) Rendition of TiO_2-CdSe nano-matchstick device. Not drawn to scale.

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