Vertical core-shell nanowire structures based on vertically aligned carbon nanofibers for dye-sensitized solar cells

Jun Li, Jianwei Liu, Jeremy Essner, Lateef Syed, Steven Klankowski

Kansas State University, Department of Chemistry, Manhattan, KS 66506

Abstract

Vertically aligned nanowire structures can facilitate charge separation and electron transfer in photovoltaic devices for solar energy conversion.[1] Here we report the fabrication of dye-sensitized solar cells (DSSCs) based on a core-shell nanowire structure using a unique template, i.e. vertically aligned carbon nanofibers (VACNFs).[2] VACNFs are multi-walled carbon nanotubes grown by plasma enhanced chemical vapor deposition, which present superior vertical alignment and unique freestanding brush-like structure.[3] Each CNF is fully separated from the neighbors by ~300-400 nm, leaving sufficient space for adding on photoactive materials and a straight mass transport pathway for mediators. A nanoneedle-textured anatase TiO_2 film was coated around each CNF as a shell of ~100 nm in thickness by metal-organic chemical vapor deposition.[4] The highly conductive and mechanically/chemically stable VACNF core serve as an ideal charge collector and the thin TiO_2 shell serves as a charge separator. This unique architecture separates the roles of charge separation and electron collection, making it possible to optimize the physical properties independently. The initial dye-sensitized solar cells were successfully fabricated with an encouraging cell performance. The advantages of higher mass transport of I_3^-/I^- mediators and potential for incorporating plasmonic nanoparticles with this vertical architecture will be discussed.

References:

(1) Law, M.; Greene, L. E.; Johnson, J. C.; Saykally, R.; Yang, P. D., Nanowire dye-sensitized solar cells. *Nat. Mater.* **2005,** *4* (6), 455.

(2) Liu, J.; Kuo, Y.-T.; Klabunde, K. J.; Rochford, C.; Wu, J.; Li, J., Novel Dye-Sensitized Solar Cell Architecture Using TiO_2-Coated Vertically Aligned Carbon Nanofiber Arrays. *ACS Applied Materials & Interfaces* **2009,** *1* (8), 1645.

(3) Lan, Y.; Wang, Y.; Ren, Z. F., Physics and applications of aligned carbon nanotubes. *Advances in Physics* **2011,** *60* (4), 553.

(4) Liu, J.; Li, J.; Sedhain, A.; Lin, J.; Jiang, H., Structure and Photoluminescence Study of TiO_2 Nanoneedle Texture along Vertically Aligned Carbon Nanofiber Arrays. *J. Phys. Chem. C* **2008,** *112* (44), 17127.