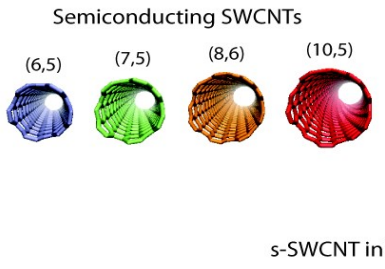
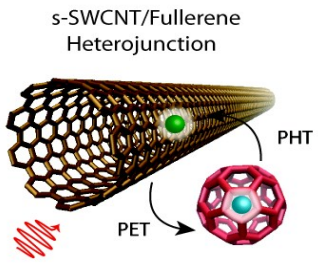
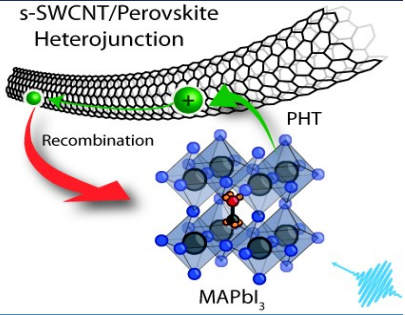
"Harvesting Energy with Semiconducting Single-walled Carbon Nanotubes"







Physical Seminar

Guest Speaker:

Jeff Blackburn

National Renewable Energy Laboratory

Monday, April 17th, 4:00pm

Hutchison Hall Room 473

University of Rochester

Department of Chemistry

Abstract:

Semiconducting single-walled carbon nanotubes (s-SWCNTs) are unique organic semiconductors with size-tunable band gaps, high absorption coefficients in the near-infrared (NIR) and visible, and extremely high charge carrier mobilities. These qualities motivate fundamental and applied studies on the use of s-SWCNTs in energy harvesting schemes, either through direct absorption in the s-SWCNTs themselves or *via* charge collection from organic or inorganic absorber layers. Relatively narrow bands of NIR radiation can be harvested through absorption in diameter-tunable excitonic solar cells.[1] Alternatively, broad ranges of thermal energy (e.g. waste heat) can be harvested in SWCNT thermoelectric (TE) materials. In this talk, I will discuss our fundamental opto-electronic studies of thin s-SWCNT films with highly tunable electronic properties. I will first discuss electrical and thermal transport in s-SWCNT films with tunable electronic structure. Fine-tuning the s-SWCNT diameter distribution and carrier density allows us to find optimal ranges for the electrical conductivity, thermopower, and thermal conductivity, enabling thermoelectric power factors that rival the highest performing polymer-based TE materials.[2] I will then discuss time-resolved spectroscopic studies of exciton dissociation at s-SWCNT:fullerene Type II heterojunctions. We have measured ultra-fast (< 100 fs) photoninduced electron transfer across such interfaces,[3] slow trap-mediated recombination (ns – μs),[4] and exciton dissociation yields that are well described by the Marcus formulation for electron transfer.[5] Finally, I will discuss the use of s-SWCNT thin films for efficient charge extraction in perovskite solar cells. The s-SWCNT charge extraction layers enable sub-picosecond removal of holes from the perovskite absorber layer, recombination times exceeding 400 μs, and improved efficiency and stability relative to traditional hole extraction layers.[6] These studies provide insight into potential routes towards the development of efficient thin-film energy harvesting systems based on s-SWCNTs.

(1) Guillot, S. L.et al. *Nanoscale* **2015**, *7*, 6556-6566.

(2) Avery, A. D.et al. *Nature Energy* **2016**, *1*, 16033.

(3) Dowgiallo, A.-M.et al. *ACS Nano* **2014**, *8*, 8573-8581.

(4) Ferguson, A. J.et al. *Physical Review B* **2015**, *91*, 245311.

(5) Ihly, R.et al. *Nature Chemistry* **2016**, *8*, 603.

(6) Ihly, R.et al. *Energy & Environmental Science* **2016**, *9*, 1439.

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