“New Photonic Material Designs for Solar Energy Conversion”

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Solar energy is currently enjoying substantial growth and investment, owing to worldwide sensitivity to energy security and climate change, and this has spurred basic research on light-matter interactions relevant to solar energy. I will describe approaches to control of light-matter interactions leading to enhanced light-trapping and absorption, as well as increased open circuit voltage and enhanced quantum efficiency in solar photovoltaic structures. Conventionally, photovoltaic cells have a physical thickness comparable to their ‘optical thickness’ for full light absorption and photocarrier current collection. Solar cell design and material synthesis considerations are strongly dictated by this simple optical thickness requirement. Dramatically reducing the absorber layer thickness or volume confers several fundamental and practical benefits, including increased open circuit voltage and conversion efficiency, and also expansion of the scope and quality of absorber materials that are suitable for photovoltaics. I will describe light absorption in thin film and wire array solar cells that demonstrate enhanced absorption compared with conventional photovoltaic cells, and limits to enhanced absorption will be explored. Plasmonics and metamaterials design can also be exploited advantageously in photovoltaics. I will describe design approaches using metallic nanostructures to enhance the radiative emission rate and hence also the photovoltaic material quantum efficiency relative to conventional light-trapping structures. Finally, future design metamaterials for broadband resonant absorption and spectrum-splitting will be discussed.

Web Resources:

LMI-EFRC: http://lmi.caltech.edu/

Resnick Institute: http://resnick.caltech.edu/

Atwater Group: http://daedalus.caltech.edu/