Nanophotonics for Solar Energy Concentration and Conversion

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Solar radiation has great potential as an abundant, clean, and renewable energy source. However, the solar power density at the surface of the earth is relatively diffuse, with average values of approximately 1000W/m^2. Thus, in order to compete with other energy sources, improved solar concentration and conversion efficiencies must be realized. In this talk, I introduce the unique optical and electronic properties of nanostructured materials that are advantageous for both solar energy concentration and conversion. This is followed with a specific description of the confinement of light via cavity modes in bilayer films of nanoscale thickness. The potential impact of cavity modes in ultrathin films on the design of solar concentrators is described, and the application to a new type of "resonance-shifted" luminescent solar concentrator (RSLSC) is introduced.[1] By spatially varying the thickness of the film so that the bilayer cavity undergoes a resonance shift, near-lossless propagation and collection of emission is observed. The prospects and necessary improvements for further utilization of RSLSCs are discussed. For energy conversion, I discuss our efforts to temporally and spatially resolve exciton generation and charge separation in photovoltaic heterostructures, beginning with the initial absorption of photons to create an electron-hole pair, to the generation and transport of free charge carriers. Specifically, the use of an ultrafast Stark shift in excitonic molecular aggregates to monitor charge separation and photovoltaic field formation in nanoscale heterostructures is described.[2] Finally, the microscopy and spectroscopy capabilities available to users of the Center for Nanoscale materials are introduced. This work was performed at the Center for Nanoscale Materials, a U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences User Facility under Contract No. DE-AC02-06CH11357.

References

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