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Presents:

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Third Generation Photovoltaics: Harnessing the Heat or “Hot” Carriers

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Sun provides more than 150,000 TW of incident radiation on earth which can easily provide us a carbon neutral source of renewable energy to meet our current needs (~15 TW). However, energetically broad distribution of the emitted electromagnetic radiation from the sun poses significant scientific challenges to harvest this energy economically. Conventionally, a semiconductor photocell absorbs this incident radiation generating electron-hole pairs across its energy bandgap, which are then collected at different electrodes to get useful electric power. However, material challenges of collecting these charge carriers before they recombine, along with fundamental challenges of utilizing the excess energy from “hot” carriers (generated by photons with energy higher than semiconductor bandgap), need to be addressed to develop clean energy sources.

Here, I will discuss my recent results on progress made in developing efficient thermophotovoltaic emitters and infrared photocells to achieve above mentioned goals. Thermophotovoltaics (TPV) is a less-studied alternative to the photovoltaic (PV), or light-to-electric, energy conversion method described above. In TPV, a secondary emitter re-emits all the incident power as an energetically narrow beam of infrared light matched to the photocell bandgap. This incident light can then be converted efficiently into electricity without incurring losses from hot-carriers. However, emission from real materials has impeded study in this area. I will show how refractory materials, like tungsten, can be easily molded into desired nanophotonic or plasmonic metamaterials to selectively tailor the glow and directionality of the emitted light. Moreover, this energy-conversion process requires using this tailored light source (or incident sunlight for PV) to generate electricity using a cheap photocell module. I will discuss my recent results in understanding charge transport and tuning recombination dynamics in thin film semiconductor devices, specifically semiconductor nanocrystals, for development of solution processable, inexpensive, infrared photocell modules. I will also discuss some fundamental advances made in thin-film plasmonics which can be beneficial not only for development of thinner solar cells, but also for developing next-generation of medical sensors, faster computer chips etc.