Carnegie Mellon
Materials Science and Engineering Seminar Series

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"From Carrier Multiplication and Hot-Electron Transfer to the Mysteries of Nanocrystal Blinking"

Friday, April 29, 2011
10:30 AM Seminar in Scaife Hall 125

Due to small, "sub-excitonic" dimensions, semiconductor nanocrystals can produce novel electronic interactions that involve charges residing in intrinsic quantized states as well as species located at nanocrystal surfaces. Strong interactions between quantum-confined carriers open, for example, a new nanocrystal-specific energy relaxation channel associated with Auger-type electron-hole energy transfer [1]. These interactions are also responsible for highly efficient nonradiative Auger recombination [2], which represents the main obstacle to applications of nanocrystals in practical lasing technologies [3]. Strong interactions between conduction- and valence-band electrons can lead to an interesting regime of photogeneration of multiple electron-hole pairs by single photons known as carrier multiplication [4]. Finally, direct coupling of nanocrystal excitations to surface species can allow for ultrafast extraction of "hot" carriers prior to their relaxation to the band-edge states [5]. The processes of carrier multiplication and hot-electron extraction have attracted significant recent interest due to their potential applications in generation-III solar energy conversion technologies.

In this presentation, I will provide an overview of our recent studies of carrier dynamics and multiexciton effects in mono- and multi-component II-VI and VI-VI nanocrystals. Specifically, I will focus on three topics: (1) carrier multiplication in relation to problems of hot-electron transfer and nanocrystal photocharging [5, 6]; (2) the roles of Auger recombination and hot-electron trapping in nanocrystal blinking as inferred from time-resolved single-nanocrystal spectroelectrochemical studies; and (3) engineered core/shell nanostructures with significant suppression of Auger recombination and unusual optical-gain properties [7, 8]. I will also discuss the implications of these studies for applications of nanocrystals in areas such as solar-energy conversion, single-nanocrystal light sources and multi-color lasing.

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[2] I. Robel *et al.*, Phys. Rev. Lett. **102**, 177404 (2009).
[3] V. I. Klimov *et al.*, Science **290**, 314 (2000).
[4] R. D. Schaller, and V. I. Klimov, Phys. Rev. Lett. **92**, 186601 (2004).
[5] J. A. McGuire *et al.*, ACS Nano **4**, 6087 (2010).
[6] J. A. McGuire *et al.*, Nano Letters **10**, 2049 (2010).
[7] F. Garcia-Santamaria *et al.*, Nano Letters **9**, 3482 (2009).
[8] F. Garcia-Santamaria *et al.*, Nano Letters **11**, 687 (2011).

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