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Intraband carrier relaxation in semiconductor quantum rods: Competition between phonon-assisted cooling and Auger heating MARC ACHERMANN, Los Alamos National Laboratory, ANDREW P. BARTKO, JENNIFER A. HOLLINGSWORTH, VICTOR I. KLIMOV — Quantization of electronic and phonon energies and large surface-to-volume ratios significantly modify energy relaxation mechanisms in nanoscale semiconductors compared to bulk materials. In the case of ultrasmall, semiconductor nanocrystals (NCs), strong quantum confinement leads to greatly enhanced carrier-carrier interactions that open new NC-specific energy relaxation and recombination channels. Here, we analyze the effect of Auger heating on the energy relaxation dynamics in elongated CdSe nanocrystals [quantum rods (QRs)]. At low carrier densities, less than 2-3 photoexcited electron-hole (e-h) pairs per QR on average, we observe bulk-like, fast, phonon-assisted carrier cooling with a time constant of around 0.5 ps. At high pump-intensities (more than 2-3 e-h pairs per QR), we detect a dramatic, orders-of-magnitude reduction in the energy relaxation rate resulting from efficient Auger heating. In this regime, energy relaxation directly correlates with recombination dynamics, which is an effect that has never been observed either in bulk or low-dimensional materials. Furthermore, we find that Auger heating differs in short and long QRs that can be explained by the difference in the scaling of Auger rates with respect to the carrier density in zero-dimensional (0D) and 1D semiconductors.

Marc Achermann
Los Alamos National Laboratory

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