Differential Transmission Measurement of Phonon Bottleneck in Self-Organized Quantum Dot Intersubband Relaxation

J. Urayama and T. B. Norris
Center for Ultrafast Optical Science and Department of Electrical Engineering and Computer Science, The University of Michigan, Ann Arbor, MI 48109-2099

J. Singh and P. Bhattacharya
Solid State Electronics Laboratory, Department of Electrical Engineering and Computer Science, The University of Michigan, Ann Arbor, MI 48109-2122

A "phonon bottleneck," or a suppression of carrier relaxation rates, is predicted for semiconductor self-assembled quantum dots because single-phonon-mediated scattering processes will be inhibited due to energy and momentum conservation requirements. However, many groups, including our own, observed fast interlevel relaxation in self-assembled dots and attributed it to Auger-type processes, intradot electron-hole scattering, or multiphonon processes. In our more recent results, we show that the bottleneck becomes observable when we remove all of these fast relaxation processes by performing a carrier capture experiment at low carrier densities. Time-resolved differential transmission measurements of self-organized $In_{0.4}Ga_{0.6}As$ quantum dots indicate a phonon bottleneck between the n=2 and n=1 electronic levels.