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Ultrafast Phenomena in Semiconductors VI

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Ultrafast Spectroscopy in Quantum Dots

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Time-resolved spectroscopy of individual quantum dots (Invited Paper),

B. B. Goldberg, Z. Liu, S. B. Ippolito, H. Robinson, M. S. Ünlü
Boston University Physics Department, Department of Electrical and
Computer Engineering, and Photonics Center; 8 Saint Mary's St., Boston MA, 02215.

More than a decade of research using optical spectroscopy to examine the physics of 3D confined quantum systems has led to a wealth of information on ensemble properties. In quantum dot systems we now understand electronic state distributions, dominant relaxation mechanisms, and morphology. Over the past several years, high spatial resolution techniques have been developed which have allowed scientists to study individual quantum dots. Using solid immersion microscopy (SIM), near-field scanning optical microscopy (NSOM), small apertures, or simply isolated, well separated dots, a very detailed picture of spin-splitting, broken degeneracies, electron-phonon coupling, and many-body effects has emerged. Quite recently, time resolved techniques have been added to individual dot spectroscopy, for instance examining the exciton and bi-exciton relaxation. In particular, pump probe techniques have been used to measure the excited state coherence in individual dots, an important element in physically realizable quantum computing architectures. This talk will review these efforts as well as our own work that has targeted an intermediate regime, where dots are close enough to be electronically and optically coupled, and where such interactions are observable in the time resolved spectroscopy. To perform these experiments we have developed a new subsurface solid immersion microscopy technique that uses the substrate as part of a 3.0 numerical aperture lens, providing $\sim 100\text{nm}$ resolution and thus isolating several dots with very high throughput.