NU-MRSEC

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Excitonics: Unraveling the structure and dynamics of excitons in quantum dots

The semiconductor quantum dot is one of the canonical systems in nanoscience. Whereas the nanometer size of these materials is obvious, the richer and more meaningful issue is the presence of quantum confinement effects conferred by virtue of size. One may qualitatively describe quantum dot electronic structure like the textbook particle in a sphere. However, this simple picture misses the vast majority of the processes which ultimately control the functionality of the quantum dot. Our goal is to obtain a detailed picture of the rich inner workings of the quantum dot. We introduce a mixed time/frequency domain ultrafast spectroscopic approach which we denote State-Resolved Exciton Dynamics. We have applied this approach to several long standing issues central to quantum dot science:

1) Hot exciton relaxation dynamics: radiationless transitions on the nanoscale
2) Optical gain: recovering predictions from theory and revealing new physics
3) Electronic structure of multiexcitons: creation of an artificial periodic table
4) electron-phonon interactions: controlling piezoelectricity on the nanoscale

The power of this approach is reflected by our ability to predict aspects of unrelated experiments, e.g. single dot blinking and multiple exciton generation. In addition to the basic science of excitons in nanoscale materials, these fundamental results have advanced the design principles for a broad range of applications including: LEDs, lasers, solar cells, THz radiation sources, piezoelectrics, and non-classical light.

For more information, please visit: http://kambhampati-group.mcgill.ca/