Fundamental optical processes in semiconductors: introduction to the feature issue

Frank Jahnke,[1] Ted Norris,[2,*] and Hailin Wang[3]

[1]*Institute for Theoretical Physics, University of Bremen, 28334 Bremen, Germany*
[2]*Center for Ultrafast Optical Science, University of Michigan, 2200 Bonisteel Boulevard, Ann Arbor, Michigan 48109–2099, USA*
[3]*Department of Physics, University of Oregon, Eugene, Oregon 97403–1274, USA*
**Corresponding author: tnorris@eecs.umich.edu*

Received December 14, 2011;
posted December 14, 2011 (Doc. ID 160046); published February 1, 2012

This feature issue is devoted to topics in fundamental optical processes in semiconductors. This is a highly active subject of research, partly due to its role in providing the physical underpinnings of much of modern and future optoelectronic technology and because it provides unique and powerful approaches to current problems in fundamental quantum physics. The issue also follows thematically the Fundamental Optical Processes in Semiconductors conferences, a series of workshops that have been held approximately biannually since 2000, focused on studies of light–matter interactions with semiconductors broadly defined. Research areas include nonlinear optical and ultrafast phenomena in direct- and indirect-gap semiconductors; graphene and carbon nanotubes; nanostructures such as quantum wells and dots; and novel materials such as metamaterials, photonic crystals, and nanoparticles.

The papers in this issue cover several of the principal themes in semiconductor optics. Optical interactions with quantum dots (QDs) have matured to the point that extraordinarily sophisticated experiments may be performed on single isolated dots. This not only enables detailed studies of the QD electronic properties unencumbered by ensemble averaging effects, but it also enables a remarkable degree of optical control of the system. Ultrafast two-dimensional Fourier transform spectroscopy enables detailed study of electronic structure, many-body effects, and relaxation mechanisms. Dynamics and control of spin—both electronic and nuclear—are optically accessible. Single QDs also provide a tremendous laboratory for quantum optics at the single-photon level, including antibunching, entangled pair generation, and indistinguishable photon generation from disparate sources.

The theme of quantum control also appears in other contexts in this issue. High harmonic generation, electromagnetically induced transparency, and ballistic current generation are all accessible via coherent excitations. Fundamental theoretical aspects of quantum control and of quantum-optical correlations are also reviewed. Spin physics is investigated in the contexts of control, ferromagnetism, and the combination of magnetic semiconductors and plasmons. The very exciting subject of polariton condensation is reviewed.

Finally, extensions of semiconductor optics to new structures are also treated, including strained GaAs nanomembranes and excitons in graphene.

The papers in this feature issue include reviews of recent progress by leaders in the field, providing a useful portal for researchers intending to enter the field and a snapshot of the state of the art in 2011. The papers include as well proposals for new directions in semiconductor optics.

0740-3224/12/02FOPS1-01$15.00/0