MAR10-2009-003031

Abstract for an Invited Paper
for the MAR10 Meeting of
the American Physical Society

Auger recombination and free-carrier absorption in nitrides from first principles[1]

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Solid-state optoelectronic devices in the blue/green part of the visible spectrum, based on group-III-nitride materials and their alloys, have a wide array of applications as well as the potential to replace incandescent and fluorescent light bulbs for general illumination. Progress in nitride light emitters research, however, is hampered by the efficiency droop effect, a severe drop in quantum efficiency at high drive currents that particularly affects devices emitting at longer wavelengths. The efficiency droop has been the subject of extensive research and several mechanisms have been proposed as its origin. One such mechanism is the Auger recombination process, a non-radiative recombination mechanism induced by free carrier scattering via the Coulomb interaction. An additional loss mechanism that affects laser devices in particular is the reabsorption of the generated light by free carriers in the device. We used first-principles calculations to study the direct as well as the indirect Auger recombination and free-carrier absorption processes, mediated by electron-phonon and alloy scattering, and identify their importance in nitride light emitters. Since the various loss processes are hard to decouple experimentally, first-principles calculations are an indispensable tool to investigate the various loss mechanisms in isolation and determine their significance.

[1]This work was supported by the DARPA Vigil Program.

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