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Impact of defects on efficiency of nitride devices[1]

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Nitride semiconductors are the key materials for solid-state lighting and also increasingly for power electronics. In both bulk crystals and epitaxial layers, point defects may act as compensating centers, charge traps, or radiative or nonradiative recombination centers. Unintentional impurities often play an equally important role; for instance, carbon that is unavoidably incorporated during metal-organic chemical vapor deposition (MOCVD) acts as a source of yellow luminescence [1]. Theoretical advances now enable us to calculate the energetics as well as electronic and optical properties of point defects with unprecedented accuracy [2]. In AlN, we have identified the defects that lead to characteristic luminescence and absorption lines [3]. Both point defects and impurities can affect the radiative efficiency of light emitters. We have developed a first-principles methodology [4] to determine nonradiative carrier capture coefficients. Accurate calculations of electron-phonon coupling, combined with results for defect formation energies and charge-state transition levels [5], enable the calculation of nonradiative capture rates for electrons and holes and the evaluation of Shockley-Read-Hall coefficients. This approach allows us to identify specific defects that play a key role in limiting the efficiency of nitride semiconductor devices.

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