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Effect of Excited State Capture on Modulation Bandwidth of Quantum Dot Semiconductor Laser with Asymmetric Barrier Layers

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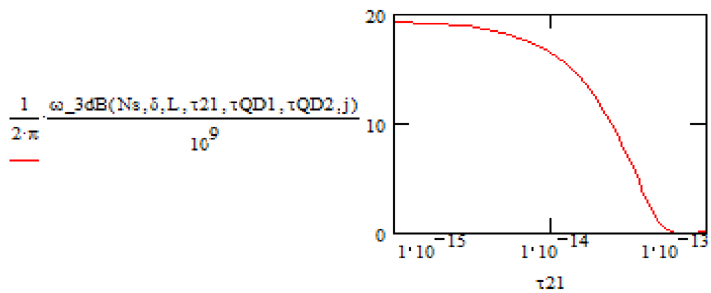
Abstract

Semiconductor lasers are used in a wide number of applications, including high speed fiber optic communications. Among semiconductor lasers, quantum dot lasers with asymmetric barrier layers offer several advantages compared to more conventional lasers. In particular, they offer lower threshold current and lower temperature sensitivity due to reduction of parasitic recombination outside of the active region. However, quantum dot lasers can contain excited states in addition to a ground state. Carrier capture can occur into one of these excited states. The delay between entering the excited state and relaxing to the ground state impacts the modulation bandwidth of the laser – the highest frequency at which the optical output of a diode laser can be efficiently modulated by the input injection current. Starting from a set of rate equations, a model for the modulation bandwidth is derived. The maximum modulation bandwidth is found as a function of the relaxation time from the excited to ground state in a quantum dot (see graph). Additionally, the effects of different parameters on the modulation bandwidth are found, including the existence of optimum values for the current and cavity length in terms of maximizing the modulation bandwidth.



Maximum modulation bandwidth (GHz) versus relaxation time (s) from excited to ground state in a quantum dot.

Biography

Cody Hammack is a first year PhD student in the Materials Science and Engineering Program. He received his BS in Physics from William and Mary in 2020. His academic focus is the study of quantum dot lasers with asymmetric barrier layers.