Intersubband Quantum Box Lasers

Peter Zory
University of Florida, USA

Quantum cascade (QC) semiconductor lasers have become of great interest in recent years since they can generate high power mid-infrared beams at room temperature.[1] However, since QC lasers have high threshold current density due to the poor radiative efficiency of the intersubband transitions utilized during lasing, high power operation appears to be limited to the pulsed regime. The radiative efficiency problem can be quantified by noting for example, that the non-radiative LO-phonon-assisted relaxation time for electrons in the upper lasing states (τ_{LO}) of a $Ga_{0.47}In_{0.53}As$ quantum well (QW) is about 1.8 ps, while the radiative relaxation time is about 4.2 ns.[2] This means that the non-radiative relaxation processes are about 2300 times faster than the radiative processes. As discussed by Benisty *et al*,[3] it appears that the value of τ_{LO} in a QW is increased substantially if its lateral dimensions are reduced substantially, converting the QW to a quantum box (QB). If so, it is possible that the radiative efficiency problem can be overcome by converting the QW active region of a QC laser into a QB array. Calculations show that an increase in τ_{LO} by a factor of about 20 in a QB array configuration eliminates the need for multiple radiative stages in order to achieve lasing on an intersubband transition.[2] In this case, the electron injector and Bragg mirror sections on either side of the active region can be separately optimized leading to additional performance improvements. With only one radiative stage, the operating voltage for this type of intersubband laser (an intersubband quantum box or IQB laser) will be substantially lower than a 25-stage QC laser. While continuous-wave (cw) operation of QC lasers at room temperature has been demonstrated,[4] the substantially lower input power requirements predicted for IQB lasers implies that they should be capable of higher average output powers than QC lasers at all temperatures. Furthermore, cw operation at room temperature with high wall-plug efficiency becomes possible.[2]

Since the publication of Ref. 3, there have been many reports of high performance interband quantum dot (QD) lasers. This appears to cast some doubt of the conclusions arrived at in Ref. 3 and therefore casts some doubt on the idea that τ_{LO} is in fact reduced when electrons are confined to QBs. The goal of this presentation is to get a number of inputs on this subject and see if a consensus can be reached.

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