Tunneling-injection quantum dot laser: ultrahigh temperature stability

Levon V. Asryan and Serge Luryi
SUNY-Stony Brook and Ioffe Institute

We propose a genuinely temperature-insensitive quantum dot (QD) laser. Ultrahigh temperature stability of operation was predicted to be one of the main advantages of QD lasers over the conventional quantum well (QW) lasers [1]. Nevertheless, despite significant recent progress in the fabrication of QD lasers, their temperature stability has fallen far short of expectations. The dominant source of the temperature dependence of threshold current is parasitic recombination outside the QDs, primarily in the optical confinement layer (OCL). In the conventional design of a QD laser, the OCL is a conductive medium where the QDs are embedded in such a way that carriers in the OCL and in QDs are in thermal equilibrium at room temperature. Consequently, the current component associated with recombination in the OCL depends exponentially on temperature and the total threshold current becomes temperature-dependent [2].

Elimination of the OCL recombination will result in a dramatic improvement of the temperature stability. To accomplish this we propose a novel QD laser design, based on tunneling injection of carriers into the QDs wherein they recombine radiatively. Direct injection of carriers into the QDs results in a strong depletion of minority carriers in the regions outside the QDs. Recombination in these regions, which is the dominant source of the temperature dependence, is thereby suppressed, raising the characteristic temperature T_0 (an all-important parameter, describing empirically the temperature dependence of the threshold current) above 1000 ^{O}K. Still further enhancement of T_0 results from the resonant nature of tunneling injection, which reduces the inhomogeneous line broadening by selectively cutting off the nonlasing QDs.

[1] Y. Arakawa and H. Sakaki, *Appl. Phys. Lett.* **40**, 939 (1982).

[2] L. V. Asryan and R. A. Suris, *IEEE J. Quantum Electron.* **34**, 841 (1998).