# Effect of inhomogeneity on quantum well far-infrared lasers

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Far-infrared (FIR) lasers working in the submillimeter range have wide uses in radio astronomy, communications and spectroscopy. In recent years, increasing research has focused on the design of FIR lasers using intersubband radiation in quantum wells (QW), e.g. [1]. Primitive experimental results [2,3] have shown the possibility of developing the structures into FIR lasers. This work discusses the effect of inhomogeneity on the QW FIR lasers.

As is well known, for a typical cavity length of $L \sim 1$mm of a GaAs/AlGaAs QW laser, the energy separations of resonant modes are $\Delta E = hc/2n_r L = 4.1 \times 10^{-12} \times 3 \times 10^{10}/(2 \times 3.72 \times 0.1) = 0.17$meV. We estimate the Lorentzian broadening to the gain width at $6.3 \sim 2.6$meV for the resonant wavelength $60\mu$m and dephasing time $T_2 = 0.21 \sim 0.5$ps [4]. This number is much greater than the cavity energy separation. Therefore QW FIR lasers will not operate on a single longitudinal mode.

Inhomogeneity caused by the variations of QW width and composition can result in the subband drifting. For a stepped QW structure [5] with composition $x = 0.45$ at the barrier, $x = 0.22$ at the stepped well and the deeper well width $l_w = 7.6$nm, a one atom layer (0.286nm) increase in the well will cause a transition energy decrease of 3.4meV between the laser subbands; while 1% change in the composition will result in the intersubband energy fluctuating by 1.3meV. These two values are similar to or greater than the half gain width. So the QWs with these fluctuations can hardly contribute to the gain. Though these two kinds of inhomogeneity are independent and may cancel (as well as add) each other somewhat, inhomogeneity will still be a critical issue in manufacture of the FIR QW lasers. Fortunately, this can be compensated by increasing the number of QWs and relying on fluctuations to ensure that a significant number contribute to the gain.

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