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Electron Population Investigation in Quantum Cascade Lasers using Femtosecond Mid-IR Pump-Probe Spectroscopy SHENG LIU, ELAINE LALANNE, ROBINSON KUIS, ANTHONY JOHNSON, Center for Advanced Studies in Photonic Research, UMBC, Baltimore, MD, 21250, USA — Femtosecond mid-IR pulses have been coupled into a room temperature 4.8μm Quantum Cascade Laser (QCL) to investigate the carrier dynamics. In the pump-probe technique a strong pump beam is coupled into the QCL to deplete or excite electrons from upper or lower lasing subband. A weaker probe beam is used to monitor the evolution of the gain as a function of the delay between probe and pump – this pump-probe signal is directly related to the electron population in the intersubband level. The 4.8μm mid-IR pulses were resonant with the QCL lasing transition, had a temporal width of 140 fs at a repetition rate of 250 kHz, synchronous to the pulsed bias. The pump-probe transmission experiment was done at different bias conditions. We observed a faster gain recovery time with increased bias, due to the dramatic reduction of upper state lifetime, because the phonon assisted non-radiative decay in a QCL far below threshold is much slower than the photon driven stimulated emission near or above threshold. At zero bias, we observed an increase in the probe signal as opposed to gain depletion by the pump pulse under high bias. Thus at zero bias, the pump excites electrons to the upper lasing level and the delayed probe experiences amplification instead of absorption.

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