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Pump-probe measurements in asymmetric stepped quantum wells using FELIX

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Abstract

Three beam pump-probe measurements in asymmetric stepped quantum wells were conducted using the FELIX free electron laser. We have measured electron intersubband lifetimes of 1.8 ps and 2.5 ps in two $GaAs/Al_xGa_{1-x}As$ stepped quantum well samples. The two samples differ in the total number of quantum wells (80 and 50 periods), donor doping concentrations at the barrier (2×10^{17} cm^{-3} and 2×10^{18} cm^{-3}) and barrier height (x=0.45 and x=0.35). Experiments were conducted on both samples at temperatures ranging from 4K to room temperature using a liquid Helium cooled cryostat. At saturation pump intensities, however, we observed an absorptive signal of sub-nanosecond lifetime following a normal positive transmissive signal of the order of picosecond lifetime. This slow decay absorptive signal is relatively stronger in intensity than the positive transmissive signal. The absorptive signal is believed to be caused by the absorption from the free electrons pumped from the ground subband to the continuum conduction band in the barrier layers associated with incoherent two-photon process. A three-level electron transition model was built to simulate the two-photon absorption process, which agrees well with the experimental data. The strong intensity dependent feature of the slow decay signal is also consistent with our model.