Optically Pumped Quantum Well Far-Infrared Laser, Resonant Intersubband Raman Process, and Coupled Electronic-Phonon Modes

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Artificial quantum well structures and intersubband transitions are promising for realizing far-infrared and terahertz emission devices. An intersubband Raman laser has been achieved based on a stimulated resonant Raman process in GaAs/AlGaAs three-level double-quantum-well structures. A CO_2 laser in resonance with the 1-to-3 transition is used as the pump, while the lasing emission occurs via the 3-to-2 transition. The 1-to-2 level spacing is designed to be in near resonance with one of the longitudinal optical phonon modes of the structure, favoring the Raman process. Intersubband lasing at 12–16 μm is reported. The presence, or lack of, lasing action provides evidence for resonantly coupled modes of collective electronic intersubband transitions and longitudinal optical phonons. An anticrossing behavior of these modes is clearly seen when the difference between the pump and lasing energies (*i.e.* Stokes Raman shift) is compared with the subband separation. This work presents an alternative mechanism for realizing intersubband lasers and opens up new possibilities in reaching the far infrared region and achieving room temperature operation. This work also reveals the significance of the strong coupling between intersubband transitions and phonons, and raises a new possibility of realizing a phonon "laser".