Peng, Peng, “Investigation of Carrier Transport in Type-II Interband Cascade Semiconductor Laser”

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There is a demand for mid-infrared wavelength (3–12 μm) sources for applications such as free-space communications, medical diagnostics, infrared countermeasures, atmospheric pollution monitoring, and infrared radar. Type-II interband cascade semiconductor lasers (ICLs) based on type-II InAs/InGaSb/AlSb multi-quantum wells show promise for applications in the 3–5μm wavelength. The performance of type-II ICLs has improved significantly in recent years. However, they are still far from optimum. Better understanding of carrier transport is one of the critical factors to optimize the laser structures.

In this dissertation, an improved and more accurate self-consistent method is presented. By using the self-consistent method, the carrier distribution and the energy band profile of type-II ICLs are calculated. A non-uniform mesh is used and a matrix transform is proven to be an efficient approach to solve Schrödinger equations and reduce the computing time. Furthermore, the energy level alignments in the carrier transport near the lasing threshold bias are simulated. Based on the self-consistent results, the influence of temperature on the carrier transport is discussed and optimized type-II ICL structures are presented near room temperature operation.

As a critical part of the type-II ICL structure, resonant tunneling diodes (RTDs) based on type-II InAs/AlSb/GaSb structures are studied experimentally for the investigation of the carrier transport. Several sizes of InAs/AlSb/GaSb RTDs are fabricated. The tunneling between the electron states of the InAs wells and hole states of the GaSb wells are observed and discussed.