**Peng, Chuan, "Tunable Semiconductor Lasers"**

*Advisor: H.Q. Le*

Mid-infrared semiconductor lasers have important applications in spectroscopy, industrial process control, bio-medical diagnostics, environmental monitoring, remote sensing, and defense. All of these applications demand a compact, reliable, and efficient mid-infrared laser source. The external cavity tunable quantum cascade laser is among the most advanced tunable laser technologies developed recently. However, an impediment to its commercial application is that the existing sources do not meet the requirements due to their narrow tuning range, noncontinuous tuning, low temperature operation, limited power, high mechanical complexity, high price, and large size. The objective of this dissertation is to investigate the tuning behavior. The results here suggest a more complex process involving fine phase control combined with coarse grating tuning for spectroscopic applications. Solving these specific problems can lead to high performance tunable mid-IR lasers.

Two factors are identified in this work as limiting the performance of the tunable mid-infrared lasers. These two factors are high intra-cavity residue reflection, which results in Fabry-Perot mode hopping, and the inaccurate grating rotating pivot point selection, which results in longitudinal mode hopping. These problems will contribute to tuning spectra discontinuity.

In this work, the experimental methods used to test the tunable mid-IR lasers are detailed, and the experiments that relate to the determination of the critical performance-limiting factors are emphasized. In order to improve the operation of these devices, methods including low temperature anti-reflectance coating, thermoelectric stabilized temperature controlled package, as well as the on-chip fine phase control segment are detailed. New tunable lasers incorporating these changes are discussed, and the performance improvement of these devices is demonstrated experimentally.

The coupled cavity model was developed for data analysis and laser design. It was based on the S-matrix method. The model can calculate the cavity mode loss envelop, longitudinal modes inside the cavity, and the laser tuning dynamics. The results from the model were compared extensively with experiments and good agreement was obtained.

Finally, some ideas for future work including the demonstration of a prototype high power mid-IR tunable laser system are presented.