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Integration of Lithographically Microfabricated Rectangular Waveguides and THz Quantum Cascade Lasers

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***Abstract*—THz quantum cascade lasers are promising solid-state sources for use as local-oscillators in THz heterodyne receiver systems. However, many challenges must still be addressed for QCLs to become practical THz sources. Among these challenges are to shape the highly divergent and non-Gaussian output beam patterns observed from QCLs into a more useful and predictable beam shape, and to integrate QCLs into the existing, broadly used THz technical infrastructure.**

To address both the beam pattern problem and integrability/manufacturability issues we have developed a lithographic method to microfabricate small, single mode rectangular waveguide structures on-a–chip. To explore the performance of the waveguides as well as the integration with active THz lasers, we have tested both stand-alone waveguides and waveguides integrated on-chip with THz quantum cascade lasers .

The 75 µm wide by 37 µm tall waveguide structures were designed to be single mode between 2 and 4 THz, and were fabricated using patterned electroplating of thick gold sidewalls around a photoresist form, followed by electroplating of a gold lid, and lastly removal of the polymer form by solvation. The waveguides were coupled to free space using 2-dimenstional H-plane horn flares.

Measurements on stand-alone waveguides with different lengths revealed a loss of 1.4 +/- 0.15 dB/mm corresponding to 0.14 db/λ. This is roughly a factor of two higher than HFSS models predict for perfect gold walls, but it still compares favorably to 0.2 db/λ at 100 GHz and 0.6 db/λ at 300 GHz for commercially available waveguides. Initial beam pattern measurements yielded qualitative data in agreement with predictions, but displayed strong high-spatial frequency amplitude oscillations. Recent measurements have identified the cause of this oscillation as being due to interference between alternate paths between the horn and detector resulting from reflections of intermediate optics. New beam pattern measurements eliminating the reflections will be presented.

We have also successfully fabricated the rectangular waveguides directly onto a chip containing multiple THz QCLs. Even though thermal stress issues caused by the need to cool the lasers resulted in a high failure rate in initial designs, we have observed QCL emission from the horns of single-spatial-mode integrated waveguides, some using only 0.2 W of input power at threshold.