Improving Transverse Mode Quality of QCLS with Novel Waveguides

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Quantum Cascade Lasers (QCLs) are reaching a level of commercial maturity. With multiple watts of CW power available from a single QCL source with near transform limited ("fundamental mode-like") beam quality. This beam quality is achievable due to the standard configuration of the QCL waveguide, with an laser core having transverse dimensions of 1-2 μm X 8-12 μm relative to the 4-5 μm wavelengths produced by higher power Midwave infrared (MWIR) devices. However, remaining with this form factor will limit the amount of available power produced by the laser, as the longitudinal extent of the waveguide cannot be indefinitely extended without issue. Multiple geometries have been explored to expand the total achievable power of single emitter beyond that of the narrow Fabry-Perot cavity, most immediately available being the broad area QCL. In this presentation, results of novel QCL waveguides fabricated at Air Force Research Laboratory are discussed.

In the "ultrawide" Fabry-Perot waveguide, extremely wide laser cores exceeding the standard configuration width by an order of magnitude allow for the scaling of average power, but with severely reduced and divergent beam quality. Through a modification of waveguide to bring the waveguide mode closer to the electrical contact, and splitting said contact into a Dual Contact Strip, the mode quality can be rectified to fundamental-like behavior.

Another approach to improving mode quality relative to the Fabry-Perot geometry is through an angled cavity waveguide. On its own, an angled cavity with a severe enough tilt may induce improved transverse mode quality, but at the expense of overall power potential through losses induced by sidewall interaction. A similar effect may be achieved by using a less pronounced angle and interrupting the waveguide with "notches" etched out of areas far from the internal beam path of the fundamental mode. This allows losses to preferentially disrupt higher order modes. Power can then be scaled by overlapping multiple angled cavities to produce a coherent array with an output beam envelope reflected by that of the output of its components in isolation.

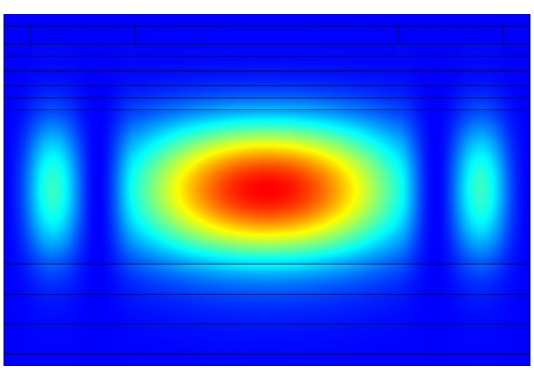

Figure 1 Simulated mode of an ultrawide QCL with Dual Contact Strip geometry.

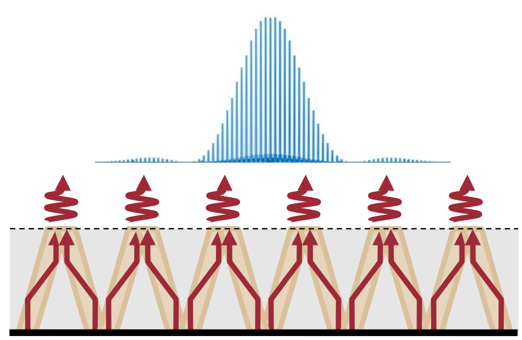

Figure 2 An overlapped angled cavity array with simulated far field.