Broadly Tunable Single Spatial Mode Quantum Cascade Lasers in an External Cavity

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Broadly tunable laser sources spanning mid- to long-wave IR are highly sought after for their ability to characterize materials with non-destructive spectroscopy techniques. The wavelengths of interest typically span 3-13 µm, or approximately 2500 cm^{-1}. Given such a large spectrum window finding materials adequately suited can be a challenge, however, given the scalability of MOCVD growth, and the wavelength agility of quantum cascade lasers, MOCVD-grown QCLs fill this niche perfectly.

Previous work has shown heterogeneous quantum cascade lasers emitting in the LWIR that span, up to 760 cm^{-1}, however, at relatively low pulsed powers and in a double-channel ridge configuration [1]. We have previously reported on tuning capabilities within an external cavity in the 4.0-4.8 µm regime [2] and here we push wavelengths across the MW- to LWIR while optimizing CW and pulsed powers with superb beam pointing stability.

This work shows advances in the tuning capabilities of single-core and heterogeneous quantum cascade structures within an external cavity. Previous state-of-the-art products would use four QCL chips to cover 1000 cm^{-1}, but here we are able to further expand the tuning range of individual chips such that the same range can be covered by only three QCLs, shown in Figure 1. Typically, the expansion of tuning range is achieved by broadening the spectral gain through either broadening of a single core, the introduction of additional cores supporting different wavelengths, or both. These different methods typically correspond to a decrease in output power; however, we show this expansion is achieved while maintaining high single mode powers. Through optimization of the active region, a relatively flat modal gain can be achieved across the desired emission range.

These devices exemplify the ability of QCLs to span significant wavenumbers, at high pulsed and CW power levels while maintaining strong single spatial mode operation which has been verified through pointing stability measurements. Beam measurements show deviations of less than 100 µrad over the range of tuning under CW and pulsed operation.

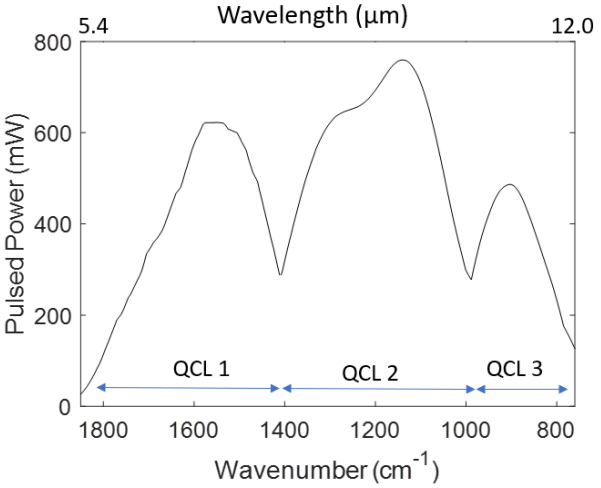

Figure 1 Three individual QCLs spanning > 1000 cm^{-1} wavenumbers under pulsed conditions

[1] D. Caffey et al. Proceeding of SPIE, (2011)

[2] N. Bandyopadhyay et al. Opt. Exp. Vol. 23, Iss. 16, pp. 21159-21164 (2015)

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