

Micro-optical bench terahertz quantum-cascade laser system

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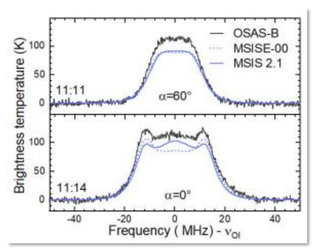
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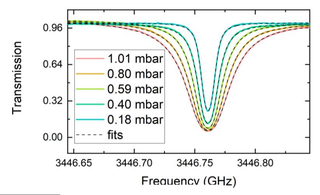
Motivation

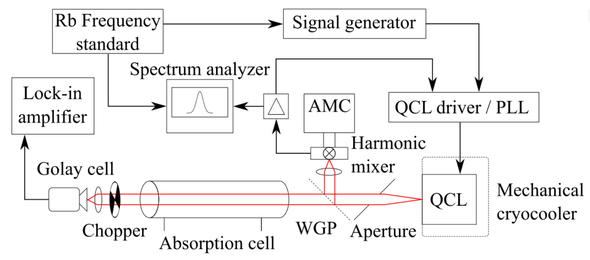
Quantum-cascade lasers (QCLs) are THz sources that offer high output power in the milliwatt range as well as very small intrinsic linewidths [1]. This is especially relevant for frequencies over 2 THz, where the output power of other sources is insufficient. QCLs are often used as local oscillators (LOs) in heterodyne spectroscopy, enabling measurement of atomic and molecular emission lines with extremely high spectral resolution compared to other techniques such as grating spectrometers and Fourier transform spectrometers. This has used on SOFIA [2] and the recently OSAS-B [3]. QCLs are also used in high resolution lab spectroscopy setups [4].





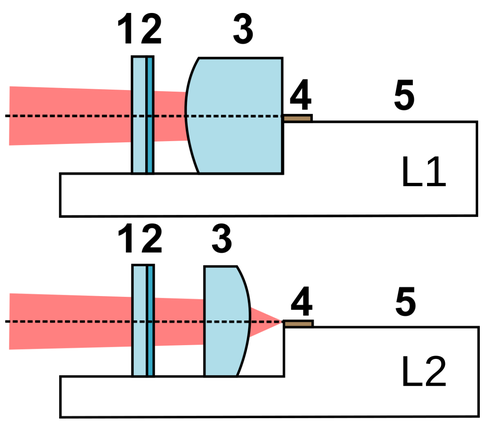




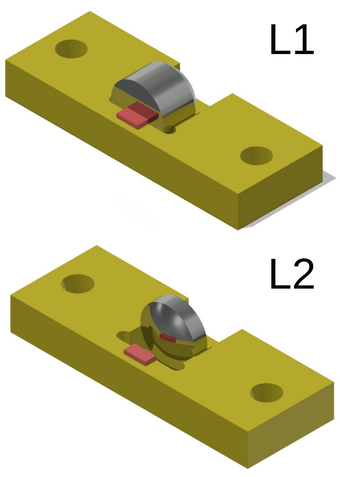


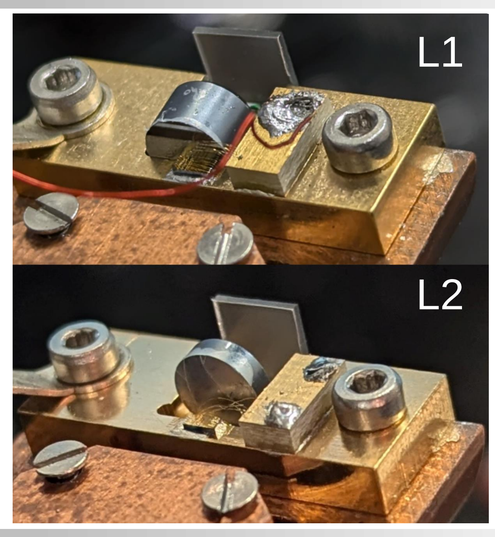
Micro-QCL Design

Our micro-integrated THz QCL design is aimed to reduce the limiting factors of QCL performance:
By integrating beam shaping optics and elements for optical isolation on the same submount as the QCL we decrease the need for additional optical elements and increase output power, while simultaneously decreasing optical feedback effects.
And while we cannot eliminate the need for cryogenic temperatures for continuous wave operation we aim to develop QCLs achieving an operating temperature of over 80K.

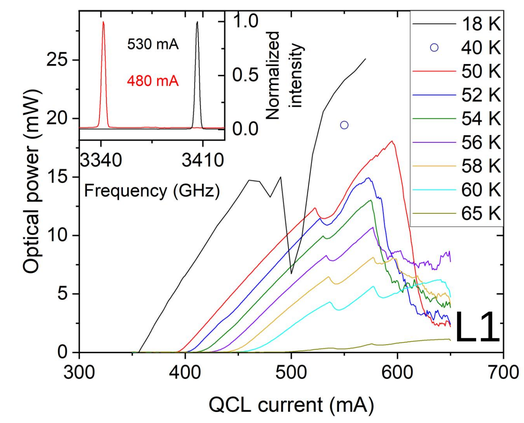


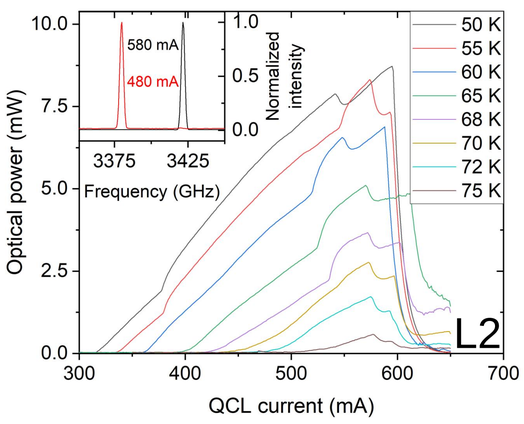
(1) λ/4 wave plate, (2) wire grid, (3) silicon lens, (4) laser chip on submount, (5) micro-optical carrier



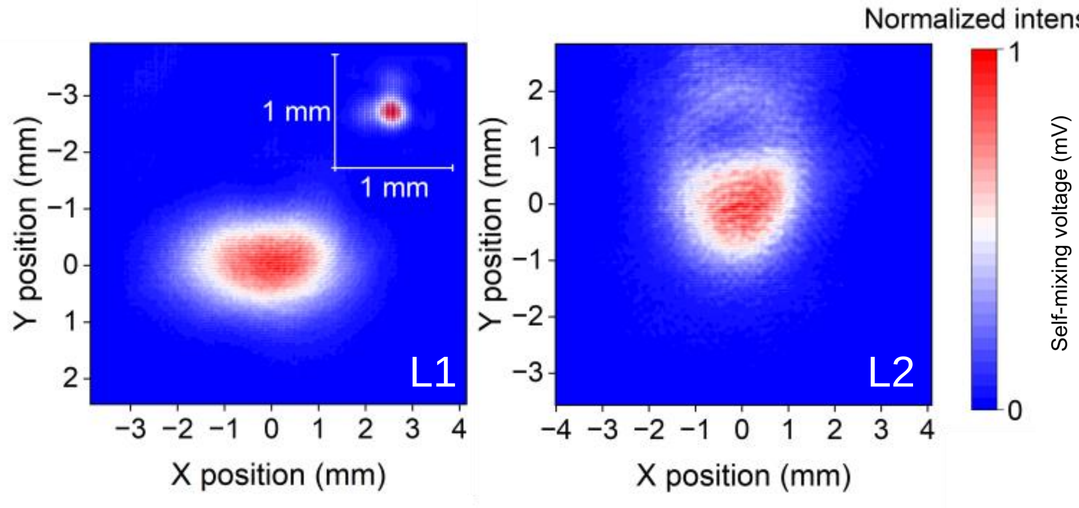


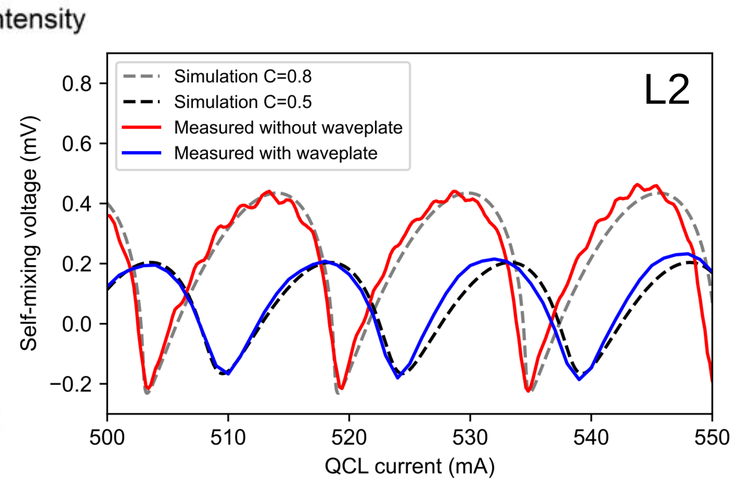
Micro-QCL Performance

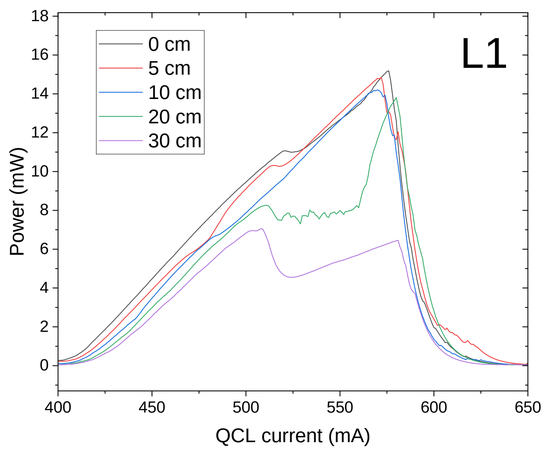


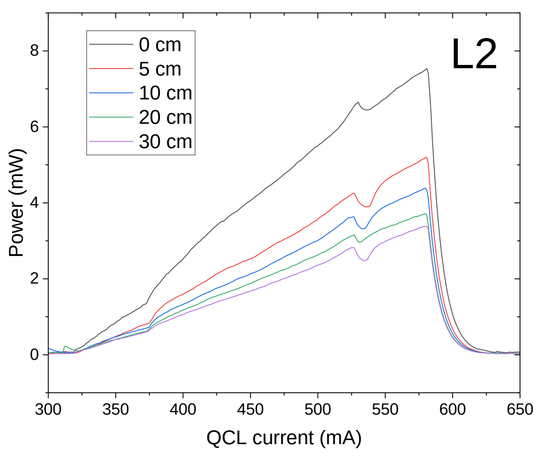


High output power of up to 20 mW in cw operation and 35 mW even at long distances due to integrated beam shaping.
Single mode operation has been achieved.









The direct contact with the immersion lens also leads to an increase in current threshold as well as increased coupling efficiency.
While this increases the output power it also increases the sensitivity to optical feedback leading to a need for better optical isolation.
Therefore using a normal aspherical lens is more suitable for spectroscopic applications while the immersion lens is suitable for applications requiring high output powers.[5]

DLR Deutsches Zentrum für Luft- und Raumfahrt

DFG INTEREST

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[5] R. Voigt, M. Wienold, X. Lü, L. Schrottke, K. Biermann, A. Sahm, K. Paschke, and H.-W. Hübers, "High-power micro-optical bench terahertz quantum-cascade laser system" IEEE Trans. Terahertz Sci. Technol. (2026)