Long wavelength distributed feedback tapered quantum cascade lasers

Davide Pinto[1,2], Kumar Kinjalk[2], Ariane Meguekam[2], Michael Bahriz[2], Bernhard Lendl[1] and Alexei N. Baranov[2]

[1] Institute of Chemical Technologies and Analytics, Technische Universität Wien, Getreidemarkt 9/164, 1060 Vienna, Austria

[2] Institute of Electronics and Systems, UMR 5214 CNRS – Université de Montpellier, 34095 Montpellier, France

We present an investigation of tapered QCLs with taper angles between 0° and 3°. Tapered cavities benefit from bigger active zone volume, preserving the beam quality of the fundamental transverse mode [1]. The QCL was based on the InAs/AlSb material system emitting around 14-15 µm [2], where BTEX compounds exhibit strong absorption, making such laser source interesting for sensing applications. The active zone is composed of an InAs/AlSb superlattice sandwiched between undoped InAs spacers and highly-doped InAs cladding layers. The wafer grown by MBE on an InAs substrate was processed into deep mesa ridge lasers using optical photolithography and wet chemical etching. E-beam lithography and dry etching were employed to pattern Bragg gratings on top of the ridge waveguide, for single longitudinal mode operation. A gold layer was deposited to provide electrical contact.

In Fig. 1(a) a scanning-electron microscope image of the tapered devices is shown. The devices were tested and compared in terms of electrical and optical properties, and in terms of spectral purity. Single-longitudinal mode operation was obtained, with a side-mode suppression ratio (SMSR) greater than 15 dB. In Fig. 1(b), emission spectra of a straight QCL, measured at different temperatures in CW operation, are portrayed. In Fig. 1(c) voltage-light-current characteristics of the tapered devices are shown. Tapers with wider angles provide a greater power output. The different improvement of the slope efficiency is observed, which can be justified by the higher collection efficiency of the system towards higher taper angle devices. The larger front facet of tapered lasers reduces the divergence angle along the slow axis, allowing to collect more light. The far-field intensity profiles were measured in order to determine the beam divergence and estimate the devices brightness.

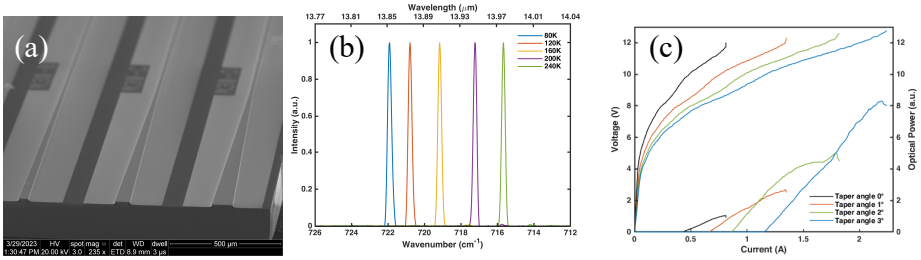

Figure 1. (a) Electron microscope image of the DFB - tapered QCLs. (b) Representative straight single mode DFB CW-spectra, with a SMSR greater than 15 dB. (c) Voltage-Light-Current curves for tapered devices, from 0° to 3° taper angles.

[1] L. Nähle, J. Semmel, W. Kaiser, S. Höfling, and A. Forchel, Applied Physics Letters 91, 181122 (2007).
[2] K. Kinjalk, D. A. Díaz-Thomas, Z. Loghmari, M. Bahriz, R. Teissier, and A. N. Baranov, Photonics 9, 747 (2022).

[+] Author for correspondence: davide.pinto@tuwien.ac.at