

ITQW 2019

Infrared Terahertz Quantum Workshop

September 15-20, 2019

Ojai, California, USA



ITQW
OJAI, CA 2019

Program and Abstract Catalog

Wednesday, September 18th

08:45-09:30 Session 10: Plenary Talk - Jérôme Faist

Chair: Daniel Wasserman

- 08:45 Jérôme Faist
Phonon-polariton lasers: optical and Raman emission (Plenary Talk)

09:30-10:30 Session 11: Frequency Combs 1

Chair: Alessandro Tredicucci

- 09:30 Katia Garrasi, Francesco Paolo Mezzapesa, Luca Salemi, Valentino Pistori, Sukhdeep Dhillon, Luigi Consolino, Saverio Bartalini, Paolo De Natale, Lianhe Li, Giles Davies, Edmund Linfield and Miriam Serena Vitiello
Quantum cascade lasers frequency combs at Terahertz-frequencies
- 09:45 Nikola Opačak, Gottfried Strasser and Benedikt Schwarz
Modelling the intra-cavity dynamics behind phase locking of quantum cascade laser frequency combs
- 10:00 David Burghoff, Ningren Han, Filippos Kapsalidis, Nathan Henry, Mattias Beck, Jacob Khurgin, Jerome Faist and Qing Hu
Microelectromechanical control of the state of quantum cascade laser frequency combs
- 10:15 Dmitry Kazakov, Marco Piccardo, Benedikt Schwarz, Maximilian Beiser, Yongrui Wang, Michele Tamagnone, Wei-Ting Chen, Alexander Zhu, Alexey Belyanin and Federico Capasso
Frequency comb generation in ring injection lasers by defect engineering

10:30-10:50 Coffee Break (Exhibition is open)

10:50-12:50 Session 12: Mid-IR Quantum-cascade lasers and interband cascade lasers

Chair: Jérôme Faist

- 10:50 Alexei Baranov, Hoang Nguyen-Van, Zeineb Loghmari, Laurent Cerutti, Jean-Baptiste Rodriguez, Julie Tournet, Gregoire Narcy, Guilhem Boissier, Gilles Patriarche, Michael Bahriz, Eric Tournié and Roland Teissier
InAs-based quantum cascade lasers directly grown on silicon (Invited)
- 11:20 Seungyong Jung, Daniele Palaferri, Feng Xie, Yae Okuno, Christopher Pinzone, Kevin Lascola and Mikhail Belkin
Monolithic integration of mid-infrared quantum cascade lasers coupled with low-loss passive InGaAs waveguides
- 11:35 Hedwig Knötig, Borislav Hinkov, Robert Weih, Sven Höfling, Werner Schrenk, Johannes Koeth, Johannes P. Waclawek, Bernhard Lendl and Gottfried Strasser
Continuous-Wave Operation of Ring Interband Cascade Lasers
- 11:50 Colin Boyle, Jeremy Kirch, Luke Mawst, Yuri Flores and Dan Botez
Impact of Interface-Roughness Scattering-Induced Carrier Leakage on High-Power, Mid-IR QCL Performance
- 12:05 Zhixin Wang, Yong Liang, Bo Meng, Yanting Sun, Giriprasanth Omanakuttan, Emilio Gini, Mattias Beck, Iliia Sergachev, Sebastian Lourduoss, Jérôme Faist and Giacomo Scalari
Large Area Surface-Emitting Photonic Crystal Quantum Cascade Laser
- 12:20 Matthew Suttinger, Rowel Go, Ahmad Azim, Enrique Sanchez, Jonathan Brescia, Dagan Hathaway and Arkadiy Lyakh
Enhanced Midwave Quantum Cascade Laser Average Power with High Duty Cycle Pulsed Operation
- 12:35 Hua Li, Ziping Li, Wenjian Wan, Kang Zhou, Xiaoyu Liao, Sijia Yang, Chenjie Wang and Juncheng Cao
Compact terahertz multiheterodyne dual-comb spectroscopy based on self-detection quantum cascade lasers

13:00-20:00 Excursion and/or Free Time (www.itqw2019.com/social-program)

The conference excursion will be held in two parts:

13:00-15:30 Visit the **Old Creek Ranch Winery** for a wine tasting and **boxed lunch**. The Old Creek Ranch Winery is Ventura County's only rural winery and is located on an 850-acre ranch. The original winery was built in the late 1800's on property formerly known as Rancho Ojai. Guests can enjoy wines while relaxing in the beautiful outdoor seating areas. (Note – if some attendees would like to skip the winery and go straight to the beach, one bus will continue directly to Ventura).

15:30-20:00 The second part of the afternoon will be an **unstructured visit to Ventura**, a charming and historical California beach town about 15 miles from Ojai. After the buses drop off in Ventura, attendees are free to enjoy the beach and explore the town for several hours. Attractions include the Ventura Beach, Ventura Pier, bicycle path, Mission San Buenaventura, and Main Street which contains many stores, restaurants, and microbreweries. Local stores will rent bicycles, surfboards, and boogie boards. Buses will return to the Ojai Valley Inn at 18:00 and 20:00.

Continuous-Wave Operation of Ring Interband Cascade Lasers

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Short Abstract We present the first interband cascade lasers (ICLs) fabricated into ring-shaped cavities emitting in continuous wave (cw) operation. A second order distributed feedback (DFB) grating is used for single mode emission and light outcoupling through the GaSb substrate. The implementation of an epitaxial-side down mounting scheme facilitates improved heat transport from the active region.

1. Introduction

ICLs [1,2] are a combination of conventional diode lasers and quantum cascade lasers (QCLs). They rely on the long upper-level recombination lifetimes of diode lasers as well as the voltage efficiency resulting from the series connection of multiple active regions as in QCLs. Due to their distinctive low power consumption, ICLs are especially attractive for portable applications in the mid-infrared spectral range, such as trace gas spectroscopy, process control and medical diagnosis [3]. ICLs fabricated into ring-shaped cavities with a second order DFB grating [4] used for the light outcoupling in vertical direction through the GaSb substrate have been demonstrated. The first devices with an outer diameter of 400 μm and a waveguide width of 10 μm showed light emission at a wavelength of $\sim 3.7 \mu\text{m}$. They were operated at low duty-cycles and showed a pulsed threshold current density below 1 kA/cm^2 at 20°C. However, for some applications operation in cw mode is required.

2. Results

Hence, we developed a second generation of such ring ICLs with smaller waveguide width of $\sim 5 \mu\text{m}$ for better suppression of higher order lateral modes together with a larger outer diameter (e.g. 800 μm) designed to achieve higher optical output power. Figure 1a shows such a new ring device, while the etched grating can be seen in Figure 1b (SEM). In addition, the new devices are designed for better heat transport from the active region by implementing an epitaxial-side down mounting scheme. Due to these improvements, we achieved cw operation at temperatures easily reached with thermoelectric cooling. Figure 1c shows a typical LIV plot at a temperature of 12°C. Two differently sloped areas can be identified in the light curve. While the device shows single mode emission at a wavelength of $\sim 4.38 \mu\text{m}$ at drive currents above 150 mA,

a second mode appears at lower currents. We are currently investigating the use of different grating parameters and an advanced epi-side down mounting scheme to further improve the device performance in cw operation. The newly developed devices are employed in a project for trace gas analysis via the principle of photothermal interferometry. Trace gas sensing using 2f-wavelength modulation (WM) Fabry-Perot photothermal interferometry has already been demonstrated with a QCL as excitation source [5]. First results of 2f-WM absorption measurements of CO using an ICL are shown in Fig. 1e. ICLs are excellent candidates for such sensors especially when it comes to compact systems for portable applications.

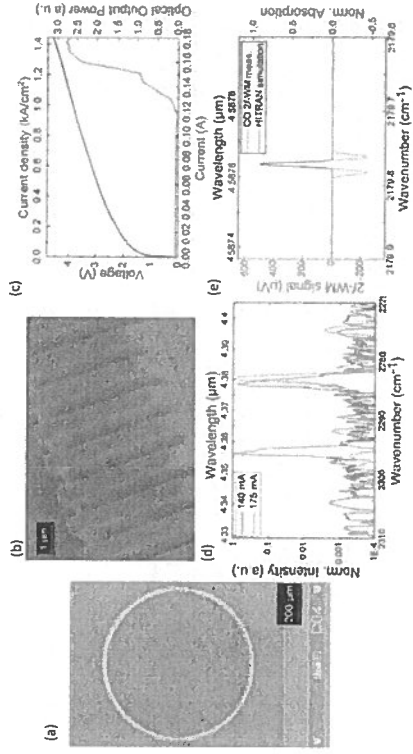


Figure 1: (a-b) SEM images of a ring device with smaller waveguide width of $\sim 5 \mu\text{m}$ and DFB grating on top (c) LIV of a ring device measured at 12°C in cw operation (d) Spectra of a ring-ICL device acquired at 12°C at 140 mA and 175 mA (e) 2f-WM measurements of CO around 2179.8 cm^{-1} using ICLs (green) together with the simulated CO-spectrum from the HITRAN database (black)

References

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- [3] R. Weih, L. Nöhle, S. Höfling, J. Koeth, and M. Kamp, Single mode interband cascade lasers based on lateral metal gratings, *Appl. Phys. Lett.* 105, 071111 (2014).
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