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Program and Abstract Catalog

Thermoelectrically Cooled Terahertz Quantum Cascade Laser

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Short Abstract We present the first thermoelectrically (TEC) cooled terahertz quantum cascade laser (QCL). A high temperature 3-well THz QCL is mounted to a novel (ΔT_{TEC}= -124 K) Peltier cooler and housing. The temperature- and time-dependent laser performance, the TEC characteristics, and the duty cycle are investigated.

1. Introduction

Since the first terahertz quantum cascade laser (QCL), there has been a push toward higher temperature devices that do not require cryogenic cooling [1]. The current T_{max} record is 199 K [2], using a 3-well $Al_{0.15}Ga_{0.85}As/GaAs$ LO-phonon scheme active region for rapid depletion of the lower laser level . Progress towards new high temperature LO-phonon designs has been achieved with 2-well active regions [3] and 3-well active regions [4], both utilizing high Al-content barriers.

Thermoelectric coolers (TEC), which utilized the Peltier effect to create a temperature difference due to an applied electrical voltage, typically reach a minimum temperature around 230 K (ΔT_{TEC} -70 K). This would require a THz QCL operating well in excess of 230 K. Multistage TECs can reach up to ΔT_{TEC} -130 K, which makes them compatible with current state-of-the-art designs.

Here we present the first thermoelectrically cooled THz QCL, using a custom housing, laser mount, and multistage TEC. We even performed some impromptu spectroscopy with the complete device.

2. Results

A high temperature $Al_{0.24}Ga_{0.76}As/GaAs$ THz QCL, design in Ref. [4], was processed into a 60×2600 µm Cu-Cu double-metal waveguide ridge. The pulsed He-cooled cryostat device performance 160–190 K is shown in Fig. 1. The output power decreases with the heatsink temperature, while the average intensity increases with the duty cycle, with the maximum limited by temperature.

The laser was mounted to a custom copper mount for vertical emission on a 4-stage TEC, in a water-cooled housing. The THz QCL performance in the TEC assembly operating at the maximum ΔT_{TEC} is shown in Fig. 2, where over 4 mW of output power is measured. The pulsed power

decreases wit the duty cycle, while the average power actually peaks at 5%. The long-term stability is related to how quickly the entire TEC assembly can dissipate the heat generated by the THz QCL.

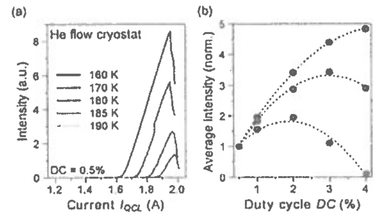

Figure 1: THz quantum cascade laser mounted in a He flow cryostat. Same active region as Ref [4] a) temperature dependent L-I-V curve. b) temperature dependent average intensity vs. duty cycle.

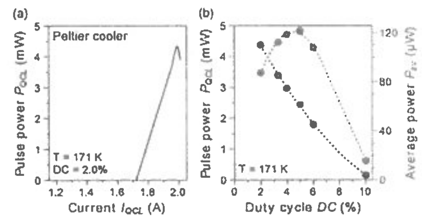

Figure 2: THz quantum cascade laser mounted on a thermoelectric cooler. a) L-I-V curve at maximum ΔT_{TEC}. b) pulsed power and average power vs. duty cycle.

References

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11:50	Martin A. Kainz, Mykhaylo Semtsiv, Georgios Tsianos, Sergii Kurlov, W. Ted Masselink, Sebastian Schoenhuber, Benedikt Limbacher, Hermann Detz, Werner Schrenk, Karl Unterrainer, Gottfried Strasser and **Aaron Maxwell Andrews** *Thermoelectrically Cooled Terahertz Quantum Cascade Laser*
12:05	**Lorenzo Bosco**, Martin Franckié, Mattias Beck, Andreas Wacker, Giacomo Scalari and Jerome Faist *Thermo-electrically cooled THz Quantum Cascade Lasers*

12:20-13:30 Buffet Lunch

13:30-15:00 Session 4: THz QCL dynamics and locking

Chair: Juncheng Cao

13:30	**Francesco Cappelli**, Luigi Consolino, Malik Nafa, Roberto Eramo, Iacopo Galli, Davide Mazzotti, Pablo Cancio, Saverio Bartalini and Paolo De Natale *Phase analysis and full phase control of chip-scale infrared frequency combs*
13:45	**Christian Georg Derntl**, Dominik Theiner, Giacomo Scalari, Mattias Beck, Jérôme Faist, Karl Unterrainer and Juraj Darmo *Spectrally resolved gain dynamics in THz quantum cascade lasers*
14:00	**Elise Uyehara**, Wendao Xu, Ali Khalatpour and Qing Hu *Offset phase-locking of two THz quantum cascade lasers for high dynamic range heterodyne imaging*
14:15	**Valentino Pistore**, Feihu Wang, Michael Riesch, Hanond Nong, Pierre-Baptiste Vigneron, Raffaele Colombelli, Olivier Parillaud, Christian Jirauschek, Juliette Mangeney, Jerome Tignon and Sukhdeep Dhillon *Active harmonic modelocking and self-starting harmonic emission in THz QCLs*
14:30	**Martin Wienold**, Tasmim Alam, Xiang Lü, Lutz Schrottke, Holger T. Grahn and Heinz-Wilhelm Hübers *Light-induced frequency tuning and stabilization of terahertz quantum-cascade lasers*
14:45	**Yohei Sakasegawa**, Shin'Ichiro Hayashi, Shingo Saito and Norihiko Sekine *Terahertz transmission responses of quantum cascade lasers over a wide range of incident electric field amplitude*

15:00-19:00 Free Time. Enjoy the resort's pools, golf, and other amenities - or just explore the local area while the sun shines.

18:40-19:00 Coffee and Snacks

19:00-20:30 Session 5: 2D Materials

Chair: Frank Koppens

19:00	**Michael Gensch** *Terahertz High Harmonic Generation in Dirac Materials **(Invited)***
19:30	**Alessandra Di Gaspare**, Eva A. A. Pogna, Francesco Pisani, Osman Balci, Allison Cadore, Cinzia di Franco, Leonardo Viti, Andrea C. Ferrari, Gaetano Scamarcio and Miriam S. Vitiello *Tunable gated graphene-on-polyimide Terahertz Modulators*
19:45	**Alexey Belyanin**, Mikhail Tokman, Qianfan Chen, Yongrui Wang, Ryan Kutayiah, Zhongqu Long, Maria Erukhimova and Ivan Oladyshkin *Infrared and terahertz optics and plasmonics of Weyl semimetals*
20:00	**Alexander McLeod** *Fundamental limits to graphene plasmonics in hBN heterostructures **(Invited)***

Tuesday, September 17th

The sessions on Tuesday September 17 are dedicated to a Focused Workshop on Polaritons and Strong Coupling Phenomena. The Focused Session is made up of a tutorial talk, invited talks, regular contributed talks, and several contributed talks upgraded to "extended" status by the program committee during the review process.

08:30-10:25 Session 6: Polaritons 1

(Part of the Focused Workshop on Polaritons and Strong Coupling Phenomena)

Chair: Raffaele Colombelli

08:30	**Alessandro Tredicucci** ***When light is more than a perturbation: what are intersubband polaritons? And how can we use them? (Tutorial)***
09:15	Chih-Feng Wang, Terefe Habteyes, Ting Shan Luk, John Klem, Hou-Tong Chen, Oleg Mitrofanov and **Igal Brener** *Near-filed Spectroscopy of Intersubband Polaritons in the Single Nanoantenna Regime (Extended)*