

Optical Engineering

OpticalEngineering.SPIEDigitalLibrary.org

Quantum and Interband Cascade Lasers with Applications

Jerry R. Meyer
Igor Vurgaftman
Gerard Wysocki

SPIE.

Jerry R. Meyer, Igor Vurgaftman, Gerard Wysocki, "Quantum and Interband Cascade Lasers with Applications," *Opt. Eng.* **57**(1), 011000 (2018), doi: 10.1117/1.OE.57.1.011000.

Quantum and Interband Cascade Lasers with Applications

Jerry R. Meyer

U.S. Naval Research Laboratory
4555 Overlook Avenue Southwest
Washington, DC 20375, United States
E-mail: jerry.meyer@nrl.navy.mil

Igor Vurgaftman

U.S. Naval Research Laboratory
4555 Overlook Avenue Southwest
Washington, DC 20375, United States
E-mail: igor.vurgaftman@nrl.navy.mil

Gerard Wysocki

Princeton University
Department of Electrical Engineering
Princeton, New Jersey 08544, United States
E-mail: gwyssocki@princeton.edu

Quantum and interband cascade lasers (QCLs and ICLs) have become important scientific and commercial technologies following their first laboratory demonstrations in 1994¹ and 1997,² respectively. Interest has continued to accelerate since the previous special section devoted to this topic appeared in *Optical Engineering* in 2010. One indicator is the rapid growth of “cascade laser” citations in the scientific literature, now exceeding 6000 per year.³ Of course, the dramatic expansion of cascade laser publications strongly correlates with novel advances in the device architectures, laser performance, and applications. This new special section of *Optical Engineering* on “Quantum and Interband Cascade Lasers with Applications” provides an overview of the status of this dynamic research topic, and attempts to capture the most recent scientific developments.

When the special section call for papers was issued in the spring of 2017, critical new progress had already occurred since the 2010 edition. This included the evolution of continuous-wave output powers from single watts to tens of watts generated by QCL arrays, the application of nonlinear difference frequency generation to produce THz radiation at room temperature, single-mode QCLs and ICLs with sufficient maturity for routine incorporation into commercial chemical sensing systems, and frequency combs based on both QCL and ICL emission. By inviting new papers contributed by many of the leading QCL and ICL research groups, our intention is not simply to survey the recent progress of these technologies, but also to outline new directions for the near future and beyond.

The 21 papers in this special section push the boundaries of device performance into several previously unexplored regions of interest. Examples include low-threshold ICLs emitting at wavelengths beyond 6 μm , high-power quantum cascade superluminescent emitters, and THz QCLs operating at ambient temperature. Of special interest at this stage are the integration and miniaturization of QCL and ICL devices and systems. Several of the papers focus on integrated laser/detector systems, micro-opto-electromechanical frequency

tuning, and fully monolithic systems for broad QCL frequency tunability. THz QCLs based on difference frequency generation have been transferred to silicon substrates, and also provide surface emission. Other papers investigate the device dynamics of QCL frequency combs, and apply ICL frequency combs to multiheterodyne chemical spectroscopy. Novel chemical detection technologies include stand-off detection with swept external-cavity lasers, and the application of multi-emitter ICL architectures to absorption spectroscopy.

The guest editors gratefully acknowledge all the authors who contributed high-quality papers to this special section, the referees for performing high-quality peer review, the *Optical Engineering* Editor, Michael T. Eismann, and the editorial staff for their valuable advice and assistance in efficiently assembling this special section.

References

1. J. Faist et al., “Quantum cascade laser,” *Science* **264**(5158), 553–556 (1994).
2. C. H. Lin et al., “Type-II interband quantum cascade laser at 3.8 μm ,” *Electron. Lett.* **33**(7), 598–599 (1997).
3. Cited after Web of Science inquiry on the topic of “cascade lasers,” (2 January 2018).

Jerry R. Meyer completed his PhD in physics at Brown University in 1977. Since then he has carried out basic and applied research at the Naval Research Laboratory in Washington, DC, where he is the Navy Senior Scientist for Quantum Electronics (ST). His research has focused on semiconductor optoelectronic materials and devices, such as new classes of semiconductor lasers and detectors for the infrared. He is a Fellow of OSA, APS, IEEE, IOP, and SPIE. He has coauthored over 370 refereed journal articles which have been cited more than 21,000 times (H-Index 61), 16 book chapters, 33 patents (7 licensed), and over 160 invited conference presentations.

Igor Vurgaftman received his PhD degree in electrical engineering from the University of Michigan, Ann Arbor. Since 1995, he has been with the Optical Sciences Division of the Naval Research Laboratory (NRL), Washington, DC, where he is currently head of the Quantum Optoelectronics Section. At NRL, he has investigated midinfrared lasers based on interband and intersubband transitions, type-II superlattice photodetectors, as well as the physics of various plasmonic and polaritonic devices. He is the author of more than 250 refereed articles in technical journals, cited more than 11,000

times (h-index of 43), as well as 20 patents. He is a Fellow of the Optical Society of America and the American Physical Society.

Gerard Wysocki is an associate professor of electrical engineering at Princeton University and the director of the MIRTHE+ Photonics Sensing Center (Mid-infrared Technologies for Health and the Environment). He received his PhD degree in physics in 2003 from Johannes Kepler University in Linz, Austria. He conducts research

focused on the development of midinfrared laser spectroscopic instrumentation for applications in trace gas detection and chemical sensing. He has published over 80 peer-reviewed publications and coauthored over 200 papers and seminars in international conferences and meetings. He is a member of OSA, APS, and SPIE and serves as an associate editor of *Optics Express*, and co-editor of *Applied Physics B*.