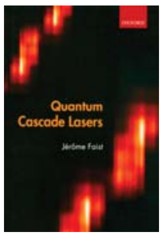
Room-temperature lasers at home on the IR range

Quantum Cascade Lasers

Jérôme Faist
Oxford U. Press, 2013. $89.95
(306 pp.). ISBN 978-0-19-852824-1

Reviewed by Igor Vurgaftman

Twenty years ago room-temperature semiconductor lasers could only operate in a narrow spectral window covering the red and the near-IR. Now their range stretches from the UV to the far-IR. Shorter wavelengths were enabled by the development of nitride semiconductors; longer wavelengths became accessible thanks largely to the invention of quantum cascade lasers (QCLs), for which the lasing transition takes place between discrete electronic states in the conduction band.



The invention of QCLs is comprehensively discussed for the first time in *Quantum Cascade Lasers*. Author Jérôme Faist and a small group of researchers originally based at Bell Labs were instrumental in developing many of the key concepts, starting from some early ideas by Rudolf Kazarinov and Robert Suris. In the preface, Faist mentions that the book sprang from a set of lecture notes, but the result is monographic in its style and disposition. It will guide the seasoned researcher looking to make a jump from an adjacent field, or it will counsel a QCL expert on a fine point of the physics. A student, however, will need a firm foundation in both condensed-matter theory and photonics to extract the full benefit.

Given the many pieces that must be joined together to form the quilt of QCL physics—including quantum-well band structure and scattering processes, mid-IR and terahertz optics, and density-matrix techniques—the temptation is to display and catalog major results as if they were big, shiny objects of obscure provenance. In spite of that peril, I found the chapters on the electronic states and inter-subband optical transitions in quantum wells to be particularly enlightening and well-organized.

The chapters on mode control and device characterization offer valuable insights, although a laser engineer accustomed to rate equations may feel intimidated when the density-matrix transport models are discussed in a subsequent chapter. And the chapters on the fabrication technology and applications of QCLs contain a wealth of information, despite their relative brevity. Overall, *Quantum Cascade Lasers* promises to become an essential complement to other popular treatments of semiconductor-laser physics, such as *Diode Lasers and Photonic Integrated Circuits* (2nd edition, Wiley, 2012) by Larry Coldren, Scott Corzine, and Milan Mašanović, and *Physics of Photonic Devices* (2nd edition, Wiley, 2009) by Shun Lien Chuang.

In a book that covers new territory, it is not hard to come up with a wish list of topics that could have been, but were not, fully addressed. In particular, an appendix to the book introduces and compiles the various QCL "active-core" designs—double-phonon, bound-to-continuum, nonresonant-extraction, deep-well, and so forth—but it skirts the issue of whether hard, statistical evidence exists for preferring one of them over another. That is regrettable because the published literature tends to feature hero designs, whereas less remarkable or negative results rarely see the light of day. An aspiring QCL designer, having turned the last page of the book, may still yearn for guidance in the matter of QCL design.

Also, the book does not devote enough attention to the relative insensitivity (as compared with most other semiconductor laser classes) of the laser threshold and slope efficiency to operating temperature, even though that property holds the key to the excellent performance of the mid-IR QCL. A more detailed analysis of the contributions to temperature sensitivity could have been quite valuable. And finally, the introductory chapter's brief discussion of the other rapidly advancing mid-IR semiconductor lasers like the type-I diode and the interband cascade laser (ICL) is already out of date. The picture painted in the book could have been completed by a short discussion of the advantages and disadvantages of each class and the applications to which each is best suited: For example, the QCL can generate much higher output power than the ICL, but it also requires much higher drive power to reach threshold.

Book reviews often conclude with a declaration that the just-listed drawbacks do not detract from the book's considerable merits. On that note, I happily join in the chorus.

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Buried Glory
Portraits of Soviet Scientists

Istvan Hargittai
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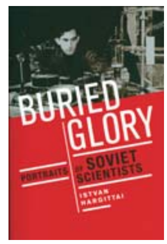
(352 pp.). ISBN 978-0-19-998559-3

The title of the latest book by Istvan Hargittai, a physical chemist and member of Hungary's Academy of Science, carries two meanings. *Buried Glory: A Portrait of Soviet Scientists* presents 13 famous scientists from the Soviet Union—all but one of them now deceased.



Also buried, Hargittai explains, is the memory of their scientific accomplishments, some of which did not receive sufficient recognition outside the Soviet Union because of linguistic, cultural, and political biases in the 20th century. Sadly, those scientists' professional heritage is being buried in today's Russia, too: In post-communist societies, the earlier tradition of privileging and supporting science at an exceptionally high level has been undermined for one full generation.

Hargittai's selection of scientists understandably includes Nikolai Semenov, Igor Tamm, Lev Landau, Andrei Sakharov, Peter Kapitza, Alexei Abrikosov, and Vitali Ginzburg—a majority of Soviet Nobel Prize winners. Their life stories are not entirely unknown to Anglophone readers, but Hargittai's biographical essays present interesting additional information based in part on his personal encounters and conversations with some of them and their Russian colleagues.