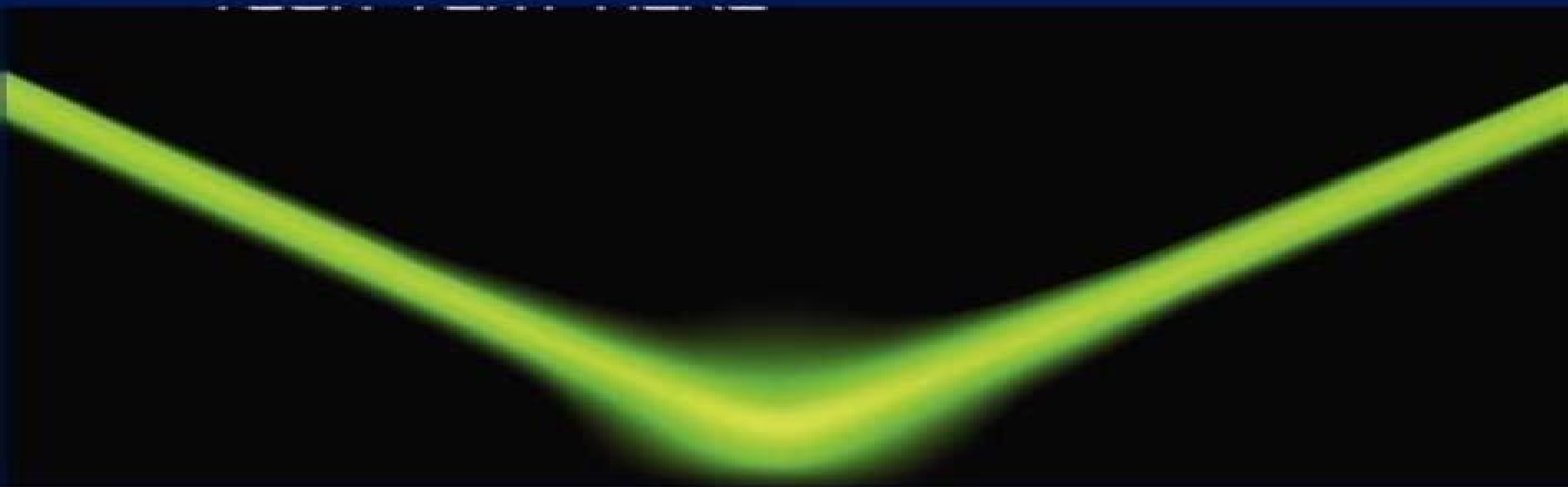




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Quantum Cascade Lasers and Optical Metamaterials

Mid-Infrared Semiconductor Nanostructures
and Their Applications



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David Patrick Burghoff



Quantum Cascade Lasers And Optical Metamaterials Mid Infrared Semiconductor Nanostructures And Their Applications:

Quantum Cascade Lasers and Optical Metamaterials Matthew David Escarra,2011 Quantum Cascade Lasers and Optical Metamaterials Matthew Escarra,2013-01 Quantum cascade QC lasers have application in areas such as medical diagnostics and homeland security Optical metamaterials have novel interactions with light and potential application for sub wavelength imaging and optical cloaking This work first explores new approaches to designing QC lasers High performance QC lasers are described with a voltage defect of only 19 meV resulting in record voltage efficiency Lasers with ultra strong coupling attain 50% wall plug efficiency The thermoelectric effect is measured for the first time within QC lasers informing further performance enhancements This work then describes two efforts to improve mid IR metamaterials Negative refraction bandwidth and dispersion properties are improved through the use of multiple metamaterial stacks QC gain regions are added to these metamaterials to reduce their absorption loss Finally QC lasers are developed for trace gas sensing of CO₂ isotopes and a techno economic model is used to value improved CO₂ isotope based sequestration leakage monitoring QC laser applications in non invasive tissue measurements inter planetary sensors C60 spectroscopy and IR countermeasures are also examined *Mid-Infrared and Terahertz Quantum Cascade Lasers* Dan Botez,Mikhail A. Belkin,2023-09-14 Discover how mid infrared and terahertz photonics has been revolutionized in this comprehensive overview of state of the art quantum cascade lasers QCLs Combining real world examples with expert guidance it provides a thorough treatment of practical applications including high power continuous wave QCLs frequency comb devices quantum electronic transport and thermal transport modeling and beam shaping in QCLs With a focus on recent developments such as frequency noise and frequency stabilization of QCLs grating outcoupled surface emitting mid infrared QCLs coherent power scaling of mid IR and THz QCLs metasurface based surface emitting THz QCLs self mixing in QCLs and THz QCL sources based on difference frequency generation it also features detailed theoretical explanations of means for efficiency maximization design criteria for high power continuous wave operation of QCLs and QCL thermal modeling enabling you to improve performance of current and future devices Paving the way for new applications and further advancements this is an invaluable resource for academics researchers and practitioners in electrical opto electronic and photonic engineering

Optically Induced Nanostructures Karsten König,Andreas Ostendorf,2015-05-19 Nanostructuring of materials is a task at the heart of many modern disciplines in mechanical engineering as well as optics electronics and the life sciences This book includes an introduction to the relevant nonlinear optical processes associated with very short laser pulses for the generation of structures far below the classical optical diffraction limit of about 200 nanometers as well as coverage of state of the art technical and biomedical applications These applications include silicon and glass wafer processing production of nanowires laser transfection and cell reprogramming optical cleaning surface treatments of implants nanowires 3D

nanoprinting STED lithography friction modification and integrated optics The book highlights also the use of modern femtosecond laser microscopes and nanoscopes as novel nanoprocessing tools *Optics Letters*, 2007

Mid-infrared Quantum Cascade Lasers for Chaos Secure Communications Olivier Spitz, 2021-05-15 The mid infrared domain is a promising optical domain because it holds two transparency atmospheric windows as well as the fingerprint of many chemical compounds Quantum cascade lasers QCLs are one of the available sources in this domain and have already been proven useful for spectroscopic applications and free space communications This thesis demonstrates how to implement a private free space communication relying on mid infrared optical chaos and this requires an accurate cartography of non linear phenomena in quantum cascade lasers This private transmission is made possible by the chaos synchronization of two twin QCLs Chaos in QCLs can be generated under optical injection or external optical feedback Depending on the parameters of the optical feedback QCLs can exhibit several non linear phenomena in addition to chaos Similarities exist between QCLs and laser diodes when the chaotic dropouts are synchronized with an external modulation and this effect is known as the entrainment phenomenon With a cross polarization reinjection technique QCLs can generate all optical square waves Eventually it is possible to trigger optical extreme events in QCLs with tilted optical feedback All these experimental results allow a better understanding of the non linear dynamics of QCLs and will extend the potential applications of this kind of semiconductor lasers *Nonlinear Photonics in Mid-infrared Quantum Cascade Lasers* Louise Jumpertz, 2017-08-31 This thesis presents the first comprehensive analysis of quantum cascade laser nonlinear dynamics and includes the first observation of a temporal chaotic behavior in quantum cascade lasers It also provides the first analysis of optical instabilities in the mid infrared range Mid infrared quantum cascade lasers are unipolar semiconductor lasers which have become widely used in applications such as gas spectroscopy free space communications or optical countermeasures Applying external perturbations such as optical feedback or optical injection leads to a strong modification of the quantum cascade laser properties Optical feedback impacts the static properties of mid infrared Fabry Perot and distributed feedback quantum cascade lasers inducing power increase threshold reduction modification of the optical spectrum which can become either single or multimode and enhanced beam quality in broad area transverse multimode lasers It also leads to a different dynamical behavior and a quantum cascade laser subject to optical feedback can oscillate periodically or even become chaotic A quantum cascade laser under external control could therefore be a source with enhanced properties for the usual mid infrared applications but could also address new applications such as tunable photonic oscillators extreme events generators chaotic Light Detection and Ranging LIDAR chaos based secured communications or unpredictable countermeasures

Quantum Cascade Lasers Jérôme Faist, 2013-03-14 This book describes the physics fabrication technology and applications of the quantum cascade laser

Characterization of Mid-infrared Quantum Cascade Lasers David Patrick Burghoff, 2009 Quantum cascade lasers provide some of the highest output powers available for light in

the mid infrared range from 3 to 8 μm . As many of their applications require portability designs that have a high wall plug efficiency are essential and were designed and grown by others to achieve this goal. However because a large fraction of these devices did not operate at all very few of the standard laser measurements could be performed to determine their properties. Therefore measurements needed to be performed that could non destructively probe the behavior of QCLs while still providing useful information. This thesis explores these types of measurements all of which fall into the category of device spectroscopy. Through polarization dependent transmission and photovoltaic spectroscopy a large portion of the quantum mechanical bandstructure could be determined along with many of the parameters characterizing crystal growth quality. In addition high resolution transmission spectroscopy was used to find the properties of the QCL waveguide. In order to find the correspondence between theory and experiment bandstructure simulations were performed using a three band p model and two dimensional electromagnetic simulations were performed to describe the laser's optical properties. These simulations were found to be in relatively good agreement with the device measurements and any discrepancies were found to be consistent with problems in the growth and fabrication.

Optical and Thermal Properties of InP-based Mid-infrared Quantum Cascade Lasers, 2007

Whispering the Secrets of Language: An Mental Quest through **Quantum Cascade Lasers And Optical Metamaterials Mid Infrared Semiconductor Nanostructures And Their Applications**

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