Integrated mid-infrared semiconductor laser frequency combs

B. Schwarz[1,2], F. Pilat[1], N. Opacak[1,2], S. Dal Cin[1], J. Hillbrand[1,2], M. Beiser[1], G. Strasser[1], R. Weih[3], S. Höfling[4], M. Piccardo[2], F. Capasso[2]

[1] *Institute of Solid State Electronics, Wien, Austria*
[2] *John A. Paulson School of Engineering and Applied Sciences, Harvard University, Cambridge, Massachusetts 02138, USA*
[3] *Nanoplus GmbH, Gerbrunn, Germany*
[4] *Institute Technische Physik, University Würzburg, Würzburg, Germany*

The increasing interest in mid-infrared sensing technology demands a scalable technology. Several challenges still need to be solved in order to integration of all mid-infrared photonic components on a single chip.

An overview of previously solved challenges as well as an outlook towards monolithic single-chip spectrometers will be provided. Compact infrared sensing instruments require the elimination of all moving parts, which is why optical frequency combs are moving into the spotlight of research. The practical realization of frequency combs from laser materials with detection capabilities is presented on two technology platforms, the quantum cascade lasers (QCLs) and interband cascade lasers (ICLs). An intuitive picture of the synchronization of states in frequency combs is provided by the analogy to coupled clocks, which provides an illustrative understanding of how these lasers can be tuned into either the pulsed (amplitude modulated) or the frequency modulated (FM) comb regime. This knowledge enabled the emission of picosecond pulses in the mid-infrared at 4 μm using an ICL and at 8 μm wavelength using a QCL, respectively.

After a review on the principles of FM comb states, I will briefly explain how the presented work can be connected to the well known complex Ginzburg-Landau equation, as well as to the Lugiato-Lefever equation, opening a new direction towards electrically pumped soliton sources.

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[3] J. Hillbrand et al. Optica **6**, 890 (2019).
[4] N. Opačak et al. Physical Review Letters 123 (2019).
[5] M Piccardo et al. Nature 572 (2020)