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IR SciX - FACSS 2019

IR-06.4 - Semiconductor Laser Frequency Combs: From Fundamentals Towards Applications

Tuesday, October 15 4:50 PM - 5:10 PM

Invited Speaker(s)

JH

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Introduction: Optical frequency combs are of paramount importance for applications requiring high precision, such as time metrology, optical communication and spectroscopy. Semiconductor laser frequency combs are a promising candidate to achieve on-chip integration of this Nobel prize winning technology. Mid-IR semiconductor frequency combs are of particular are of particular interest, because they allow to measure molecular fingerprints within microseconds of acquisition time without the need of moving parts. Methods: We investigate the locking mechanism and temporal dynamics of mid-IR quantum cascade laser (QCL) frequency combs. Using an ultrafast quantum well infrared photodetector (QWIP) and a Fourier-transform infrared spectrometer (FTIR), it is possible to assess the coherence of the comb and reconsruct the laser intensity as function of time. Furthermore, we investigate the possibility to lock the comb to an external radio-frequency reference. This allows to conveniently control the frequency comb with simple and cheap electronics as those found in every mobile phone. Finally, we investigate mid-IR interband cascade laser (ICL) frequency combs as low power consumption alternative to QCLs. Results: Our experiments show that QCL frequency combs operate fundamentally different from conventional femtosecond laser frequency combs. Instead of emitting short pulses, the intensity of the QCL remains almost constant while showing a strong frequency chirp. By injecting a RF signal close to the roundtrip frequency directly into the laser, it is possible to lock the QCL to an external reference. The locked QCL comb proves to be much more robust against the harsh conditions in real-life conditions such as intense optical feedback. A prototype dual-comb chip highlights the potential for all-solid-state spectrometers. ICL frequency combs are a novel alternative to QCLs. They consume less than 1 W of total power and thus can be driven with cheap electronics. Interestingly, they show exactly the same frequency comb state as QCLs, despite having a different active region. Another advantage of ICLs is the possibility to build sensitive and high-speed detectors from the very same epitaxial material as the laser active region. Conclusion: Our findings open up new avenues towards robust and compact dual-comb spectrometers.