Frequency modulated comb generation in quantum well laser diodes

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Semiconductor lasers (SLs) operating in the mid-infrared (3–5 μm) spectral range play a vital role in sensing applications [1]. Commercially-available single-mode sources for tunable diode laser absorption spectroscopy (TDLAS) have limited spectral coverage; therefore, recent efforts focus on generating broadband optical frequency combs (OFC) for sensing complex organic molecules. One of the most widespread techniques for obtaining OFC emission in SLs relies on passive mode-locking through an on-chip saturable absorber [2]. However, there is a fundamentally different approach to generating OFCs in single-section Fabry-Pérot devices, which has shown to be compatible with a wide class of SLs, namely self-starting frequency-modulation (FM) [3]. Here, we exploit this mode triggered by the inherent gain nonlinearity and demonstrate a broadband OFC self-generated in a GaSb-based quantum well diode laser (QWDL) at a 3 μm wavelength [4] (Fig. 1a). A pair of devices with kHz-wide intermode beat notes (Fig. 1b) was used for free-running mode-resolved dual-comb spectroscopy (Fig. 1c) even under battery operation. We will discuss the unique spectral properties and tunability of the QWDL combs enabled by careful waveguide engineering.

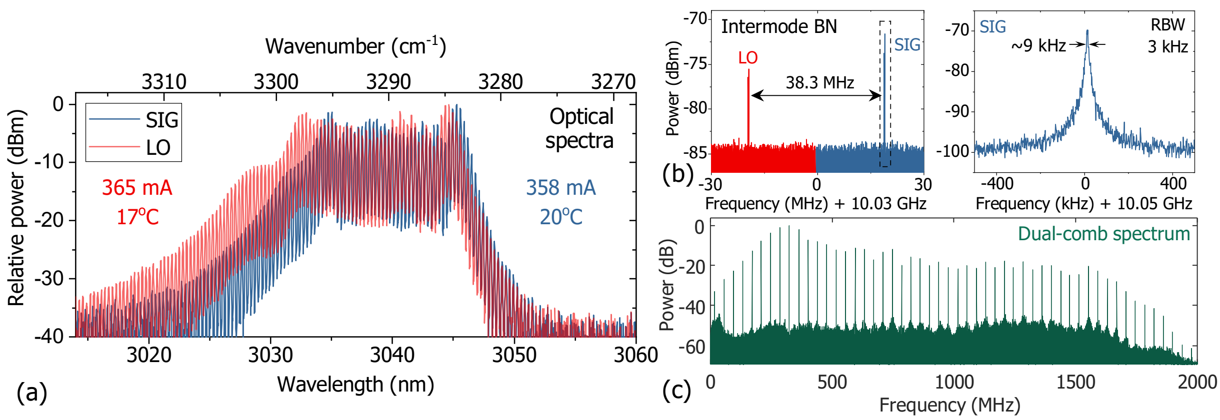

Fig 1. (a) Optical spectra of two QWDL devices. (b) Radio-frequency intermode beat notes. (c) Phase-corrected dual-comb spectrum (1 ms) resulting from multiheterodyne beating between the two combs.

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