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SUPPLEMENTARY INFORMATION
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Octave-spanning semiconductor laser

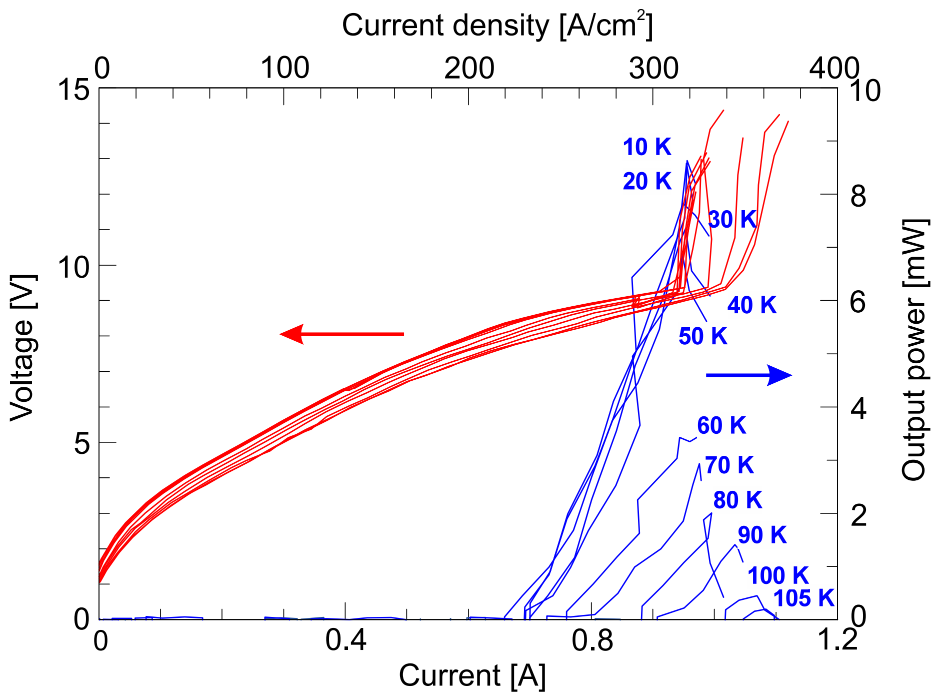
Markus Rösch,[a] Giacomo Scalari,[b] Mattias Beck, and Jérôme Faist

ETH Zurich, Institute of Quantum Electronics,

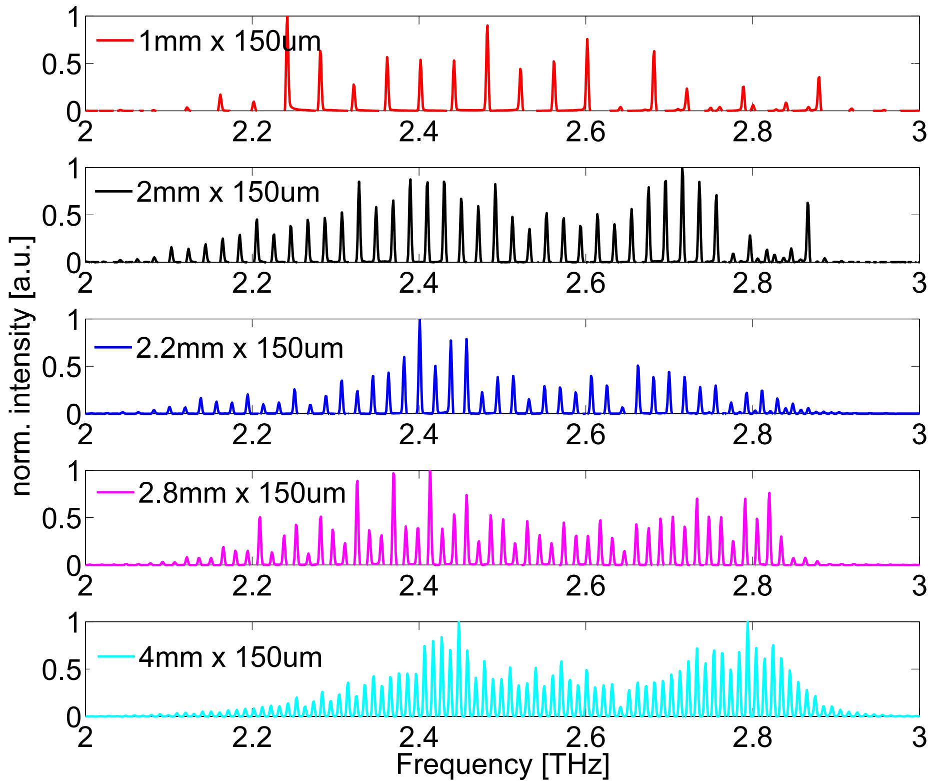
Auguste-Piccard-Hof 1, Zurich 8093, Switzerland

[a]mroesch@phys.ethz.ch

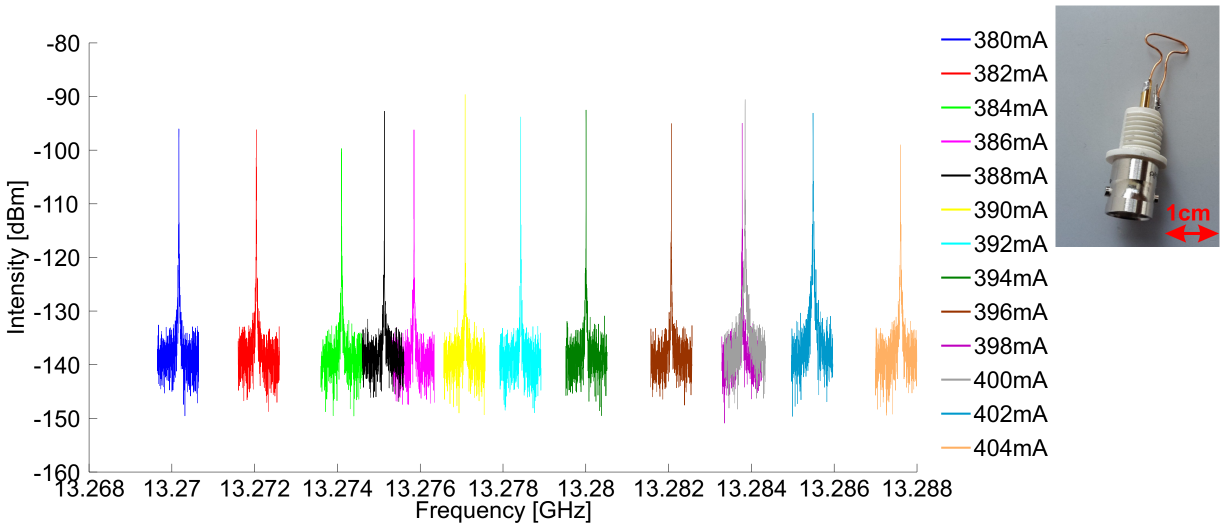
[b]scalari@phys.ethz.ch



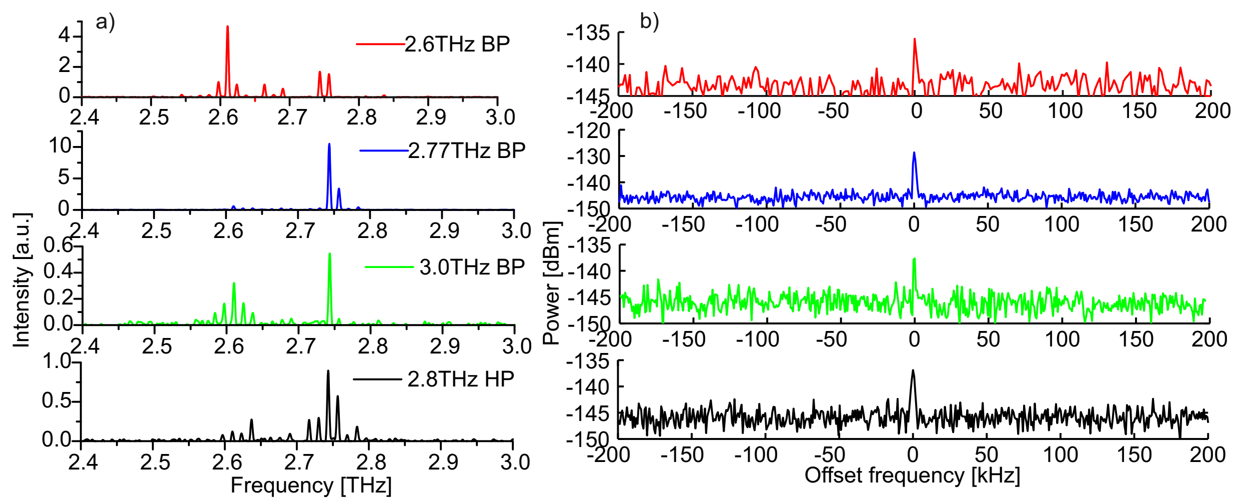
Supplementary Figure 1. Pulsed LIV characteristics: Measured LIV characteristics for a 2 mm x 150 μm wet-etched laser measured in pulsed operation at different temperatures. A maximal peak power of 8.5 mW is achieved for a current $J_{max} = 1.5J_{th}$.



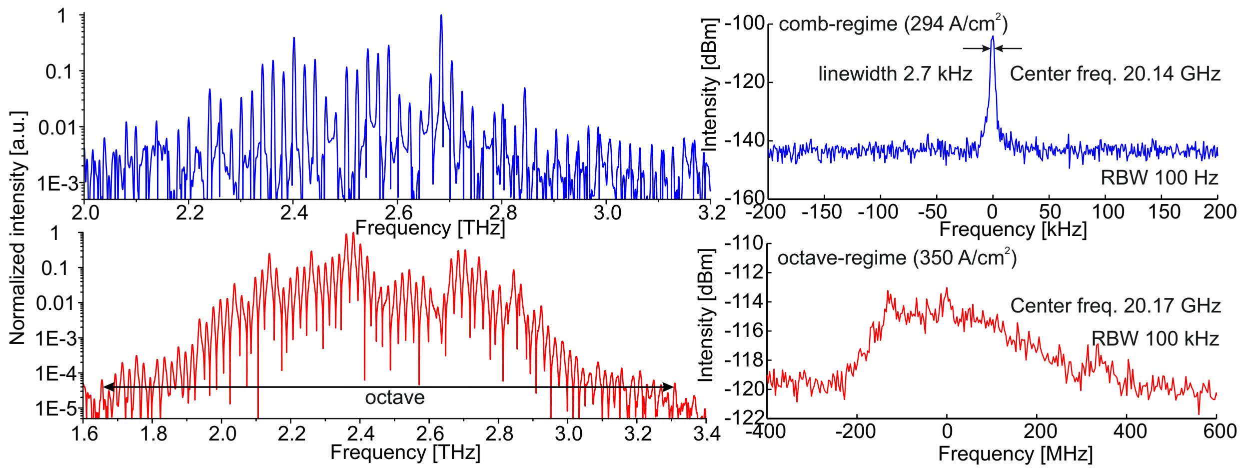
Supplementary Figure 2. Spectral performance as function of cavity length: Emission spectra for lasers with cavity lengths of 1 mm, 2 mm, 2.2 mm, 2.8 mm, and 4 mm. All these lasers are wet-etched and are 150 μm wide. Due to the different round-trip frequencies the mode-spacing of the Fabry-Pérot modes for the individual lasers is different while the spectral range stays almost identical. They were measured in pulsed operation (f_{rep} = 150kHz, 5% duty cycle) at 10 K with an under-vacuum FTIR.



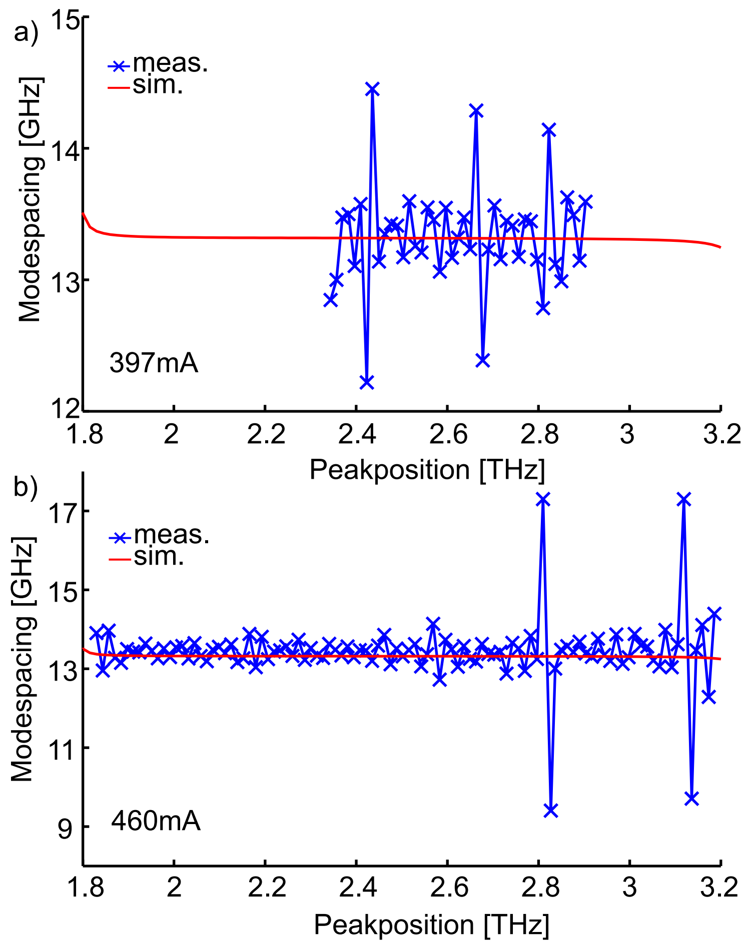
Supplementary Figure 3. Frequency comb beatnote: Measured electrical beatnotes of a 3 mm x 50 μm laser for different bias currents throughout the entire comb region indicated in Figure 3 of the main article. The measurements were performed at 25 Kelvin with a RBW of 1 kHz. Inset: Picture of the home-made folded dipole antenna used for the electrical beatnote measurements.



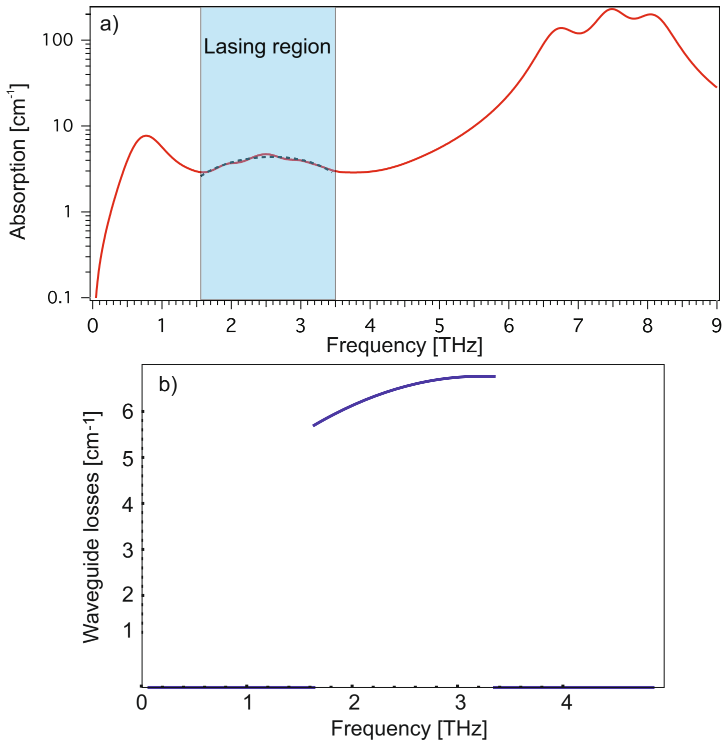
Supplementary Figure 4. Filtered frequency comb: a) The optical spectrum of a 3 mm x 50 μm laser at a current of 397mA and a temperature of 25 Kelvin measured with an FTIR and filtered using different types of filters. The first three filters are band-pass filters based on complementary splitring resonators (red, blue, green). For the first two the center frequency matches the laser spectrum (2.6 THz, 2.77 THz), while for the third we are measuring on the low frequency tail of the filter (center: 3.0 THz). The fourth filter (black curve) is a 2.8 THz high-pass mesh filter (0.1 mm thick layer of molybdenum with 60 m holes). For the latter two filters we profit from the fact that the absorption curves are not flat and are therefore transmitting frequencies in an uneven way. b) Corresponding optical beatnotes measured with a corner cube Schottky diode detector (Farran Technology Inc.) after filtering the laser light using the filters described above, and the same operating conditions as for the FTIR measurements.



Supplementary Figure 5. Additional comb analysis: Optical spectra and electrical beatnote measurements for an octave-spanning, 2 mm x 50 μm laser at two different currents. On top the laser is in the comb regime while on the bottom the laser is in the broad beatnote regime featuring an octave-spanning spectrum. This shows that comb operation is also possible on octave-spanning devices, although not over the entire octave.



Supplementary Figure 6. Modespacing: Effects of dispersion on the modespacing. a) For 397 mA we do not observe any change in the modespacing, while b) for 460 mA slight changes are visible as predicted by our simulations (red curves). A more visible approach to show the effects of the dispersion is presented in Fig. 4b and 4c with the same data.



Supplementary Figure 7. Calculated laser losses: a) Losses due to intersubband absorption in the active region. The dashed line displays a polynomial fit for the lasing region. b) Calculated waveguide losses for a 50 μm wide and 13 μm high metal-metal laser cavity. Both losses were combined and a constant mirror loss of 1.6 cm^{-1} was added in order to get the clamped gain curve in figure 5a.