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Theory of frequency modulated combs in semiconductor lasers

Multi-mode emission from a THz Quantum Cascade Ring Laser

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Quantum Cascade Lasers (QCLs) are powerful sources for coherent emission in the mid-infrared and terahertz spectral region [1]. Recently presented concepts for broadband active regions demonstrate octave-spanning emission [2]. Commonly used waveguide concepts include ridge type resonators supporting Fabry-Pérot modes. While this resonator type provides high temperature operation, it suffers from spatial hole burning, preventing the exploitation of the whole gain bandwidth of the active region [3]. Therefore, new cavity designs are investigated to overcome this limitation.

Here, we report on ring-shaped resonators fabricated in a double-metal waveguide. Ring cavities with different design parameters (width and radius) were fabricated and characterized. The devices measured at 10 K in pulsed operation mode (1 µs, 10 kHz, corresponding to 1 % duty cycle) exhibit a lasing threshold of ~680 A/cm², which is comparable to a ridge-shaped reference device (Fig. 1). The multi-mode emission spectrum of the ring is shown in Fig. 2.

Due to the fact, that the ring is emitting from the edges, only a fraction of the emitted light is currently coupled into the Fourier transform infrared spectrometer (FTIR) and collected by the detector. Further optimization of the ring cavities, employing special collecting features will dramatically enhance the collection efficiency.

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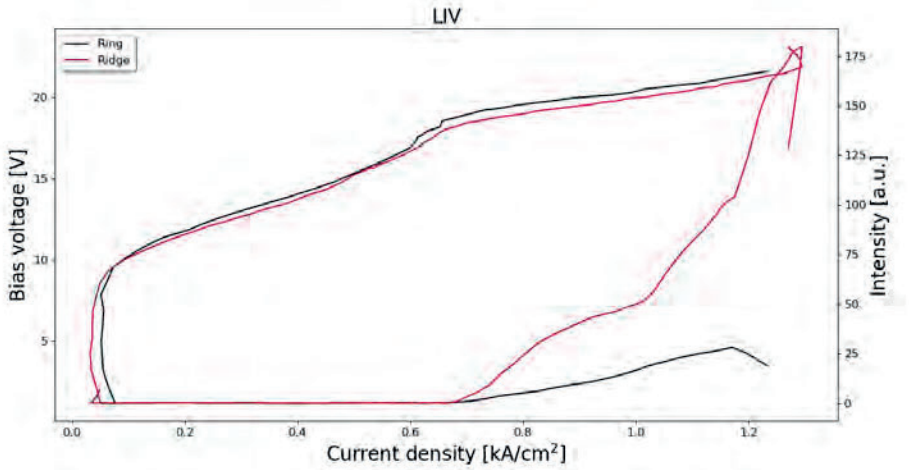

Fig. 1: Light-current-voltage diagram of a ring-shaped resonator and a ridge type reference resonator

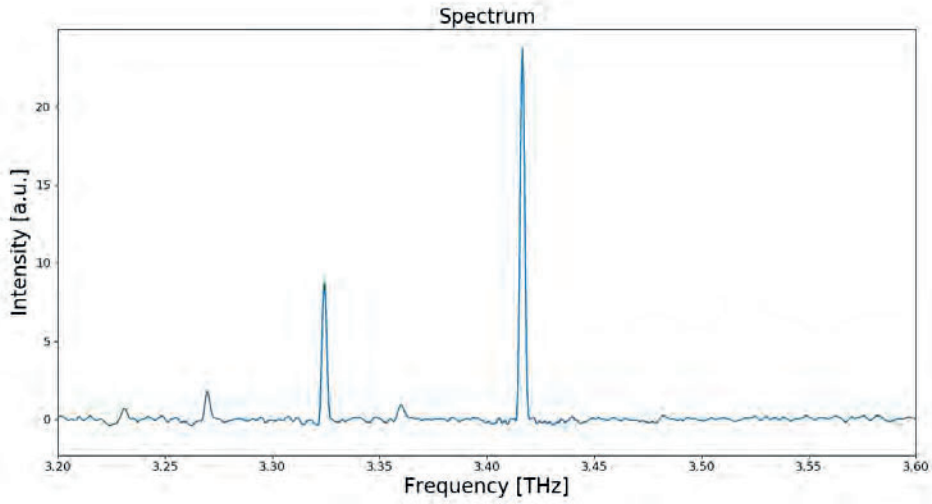

Fig. 2: Multi-mode emission spectrum of a ring-shaped resonator