High-Q Resonant Cavities In The Terahertz Range: Optical Feedback Effects On Quantum Cascade Lasers

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Optical resonators are well-established tools used in spectroscopy. The underexploited portion of the electromagnetic spectrum ranging from 0.1 to 10 THz, known as "terahertz", is still lacking of such tools. Recent advances in generation and detection of THz radiation, as well as the advent of THz quantum cascade lasers (QCLs), are now making THz light emerge as a new promising frontier for many research areas. Cavity resonators represent an attractive tool to further increase the sensitivity of a spectroscopic system, but design and fabrication of cavities resonating at THz frequencies are challenging. We report on the realization and characterization of two different designs (V-shaped and ring-shaped) for resonant THz cavities injected by a continuous-wave QCL emitting at 2.55 THz. We used wire-grid polarizers as high-reflectivity/low-transmission input/output couplers and equipped each cavity with a shifting mirror, in order to tune the cavity length. With the best values achieved for their finesse (F=63) and quality factor (Q=260,000), these cavities showed resonant peaks as narrow as few MHz, comparable with the typical Doppler linewidth of THz molecular transitions and slightly broader than the free-running QCL emission spectrum. In particular, the V-shaped resonator, when in resonance condition, generated optical feedback to the QCL, that, broadening the resonance peak profiles, prevented accurate finesse measurements. By simultaneously coupling the same THz QCL to both cavities, the effect of optical feedback from the V-shaped cavity to the laser was investigated. We injected both the resonators at the same time: the V-shaped cavity was swept across its resonances, while the ring cavity was kept fixed at a resonance half-height. In these conditions, any shift of the laser frequency induced by the optical feedback from the V-shaped cavity was measured as a variation of the signal retrieved from the ring-shaped cavity.