Coupling Strategies for Coherent Operation of Ring Cavity Surface Emitting Intersubband Lasers

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Since quantum cascade lasers (QCLs) [1] represent compact reliable coherently emitting devices in the mid infrared (MIR) and terahertz (THz) spectral region, investigations with respect to their material system and especially their resonator design are highly appreciated. The fact that their emission spectrum is rich in molecular absorption lines opens a wide field of real world applications including gas analysis for environmental and medical uses as well as chemical sensing. Since several tasks call for high optical output power, considerations in this direction become essential. Here, we report fundamental investigations on the capability of coherent operation of an arbitrary number of QCL devices. The gained results open up numerous future prospects for coupled QCLs, up to two dimensional QCL arrays for powerful, monochromatic emission at room temperature. Recently, our group presented an ideal elementary building block for two-dimensional laser arrays, the ring cavity surface emitting lasers (RING-CSELs) [2]. This resonator type provides the feasibility of producing symmetric low divergence optical beams combined with single-mode operation, reduced thresholds and enhanced radiation efficiency. It incorporates a ring shaped resonator, holding a second order distributed feedback (DFB) grating on top that acts as a Bragg reflector for surface light extraction. Its comparable large emission area in combination with an absence of facets make RING-CSELs show considerably enhanced properties in comparison to conventional edge emitting Fabry-Perot lasers. The present investigations on coherent coupling are executed using high performance RING-CSELs based on a InGaAs/InAlAs/InP material system with 8.05 µm nominal emission wavelength, as recently published by our group [3 and references therein].

Coherent coupling plays an important role since it results in a significant enhancement of the spatial and spectral brightness. This application promises not only power enhancement under retention of coherence, coupled devices with different resonators can achieve remarkably increased overall mode selectivity by exploiting the Vernier effect. Different approaches showed optimal coupling for a coupling- gap of 1 µm. At this geometry, where two separated lasers couple via their evanescent field, a balanced relation between intercavity losses and sufficient coupling strength for robust coherence was achieved [4]. Furthermore, a geometry of directly coupled resonators is presented that features single mode emission at room temperature. These coherently coupled device pairs exhibit an interference far field pattern.

References

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