Towards a widely tunable integrated Quantum Cascade Laser

Aditya Malik
Department of Information Technology, Ghent University, imec, Center for Nano and Biophotonics (NB-Photonics)

Supervisor(s): Gunther Roelkens

The mid-infrared wavelength region is of great interest for spectroscopic applications primarily because many of the gases which we want to detect have very strong absorption bands in this wavelength range.

The most important part of any spectroscopic system is a compact, tunable and low-cost light source. In classical semiconductor lasers, the wavelength of the emitted light is determined by the bandgap of the semiconductor material used and hence beyond a certain wavelength emission is not possible. Quantum cascade lasers (QCLs) produce light via intersubband transitions and hence offer a platform for light emission in the mid-IR (3-15 microns).

The present state of the art QCL systems achieve tunability through an external grating which makes the final device bulky and expensive. Integration of these lasers on photonic chips can provide a low-cost and ultra-compact light source on a chip. The major requirement in producing tunability from a photonic chip is having a low loss waveguide circuit with good coupling efficiency to the QCL gain media. The classical Silicon on Insulator waveguides are not suitable for applications beyond 3.5 microns and hence we propose alternative waveguide platforms namely Germanium on Silicon, Silicon on Sapphire and Silicon on Silicon Nitride.

The QCL chip will be integrated with the passive photonic chip via flip chip integration. Therefore, coupling structures from the QCL gain medium to the photonic waveguide and wavelength selective feedback elements like ring resonators are required on the passive waveguide circuit. The tunability of the laser is achieved through these feedback elements which couple light back to the QCL gain chip.