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S E M I N A R
aus
Halbleiterphysik und Nanotechnologie

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"On-chip and remote sensing Sensing with Quantum Cascade Devices"

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Optical sensors for mid-infrared spectroscopy are widely used in industrial and environmental monitoring as well as medical and biochemical diagnostics. We present a sensor concept, based on a bi-functional quantum cascade heterostructure, for which the differentiation between laser and detector is eliminated. This enables mutual commutation of laser and detector, simplifies remote sensing setups and facilitates a crucial miniaturization of sensing devices.

Liquid sensing utilizing bi-functional quantum cascade lasers/detectors (QCLDs) can be realized on a single chip. A QCL active region design with an additional detection capability at the laser emission wavelength allows a straightforward integration, where different parts of the chip are used for lasers and others for detectors. The performance of such bi-functional designs has been optimized to reach a similar laser performance as conventional QCLs, allowing for high power operation at room-temperature. Sensing liquids utilizes surface plasmon polaritons to allow a strong interaction within a short distance. Different distributed-feedback-laser/waveguide/detector units can be combined on a single chip, to use the inherent selectivity of the mid-infrared region.

Typical analyte interaction lengths for gas sensing are in the range of tens of centimeters or more and exceed the common semiconductor chip sizes. Our gas sensing approach incorporates surface-active lasers and detectors. The latest demonstrator consists of two concentric ring QCLDs with second order distributed feedback (DFB) gratings on top of the waveguides. These DFB gratings facilitate vertical light emission and detection in the biased lasing and unbiased detector configuration, respectively. The two rings emit at two different wavelengths, which provides room temperature lasing and detection of two wavelengths monolithically integrated on the same chip.