Monolithically integrated quantum cascade laser and detector

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Quantum cascade lasers (QCLs) are known as one of the most important and influential sources in the mid-infrared region. In the so called "fingerprint" region (3-20µm) most molecules have their resonances, that can be observed by optical absorption or a change of the refractive index of the chemical substance. The miniaturization of spectroscopic setups is a fascinating research topic, gaining momentum during the last couple of years. Many chip-scale sensing concepts have been demonstrated utilizing quantum cascade lasers. However, all of these concepts have been demonstrated with external optics and detectors.

We have recently demonstrated a quantum cascade device that can act as both laser and detector over the same wavelength range [1]. Simply by changing the applied bias, the structure switches between lasing (58kV/cm) and detection (0kV/cm). Based on this bi-functional active region, we have integrated a laser and a detector on the same chip [2], as illustrated in Fig. 1 (left). We have observed an on-chip detector signal of 191.5mV at room-temperature. The light power versus current density plot of the laser, comparing the on-chip detector with an external DTGS detector is shown in Fig. 1 (right). By separating the contacts of the laser and the detector we were able to reduce the electric cross-talk below 2mV at laser threshold.

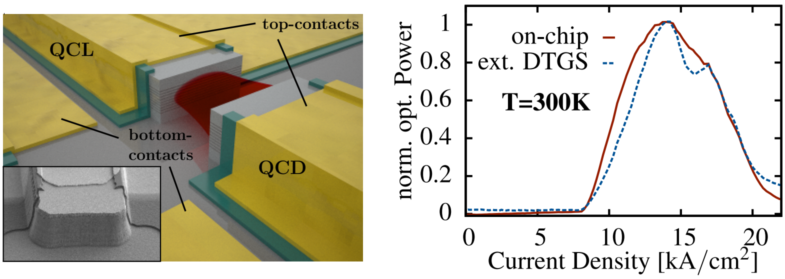

Fig. 1 Sketch of the monolithically integrated laser and detector (left) [2]. The inset shows the etched laser facet. Optical power of the laser measured with the on-chip detector at the back facet and with an external DTGS with a lens at the front facet (right). We have observed a peak detector signal of 191.5mV at room-temperature.

By combining QCLs with detector capabilities, we introduce an alternative way to develop more compact monolithic systems for mobile chemical fingerprinting, without any external detector and lens and without wafer bonding on a different technology platform. The structure can be used as a mid-infrared sensor when combined with microfluidic channels, or alternatively to monitor the power of QCLs. Due to the relative broad gain, our active region can be combined with single mode cavity arrays to give spectral resolved information of different chemical substances with greater selectivity.

[1] B. Schwarz, P. Reininger, H. Detz, T. Zederbauer, A. M. Andrews, S. Kalchmair, W. Schrenk, O. Baumgartner, H. Kosina, and G. Strasser, Appl. Phys. Lett. **101**, 191109 (2012).

[2] B. Schwarz, P. Reininger, H. Detz, T. Zederbauer, A. M. Andrews, W. Schrenk and G. Strasser, Sensors **13**, 2196 (2013).