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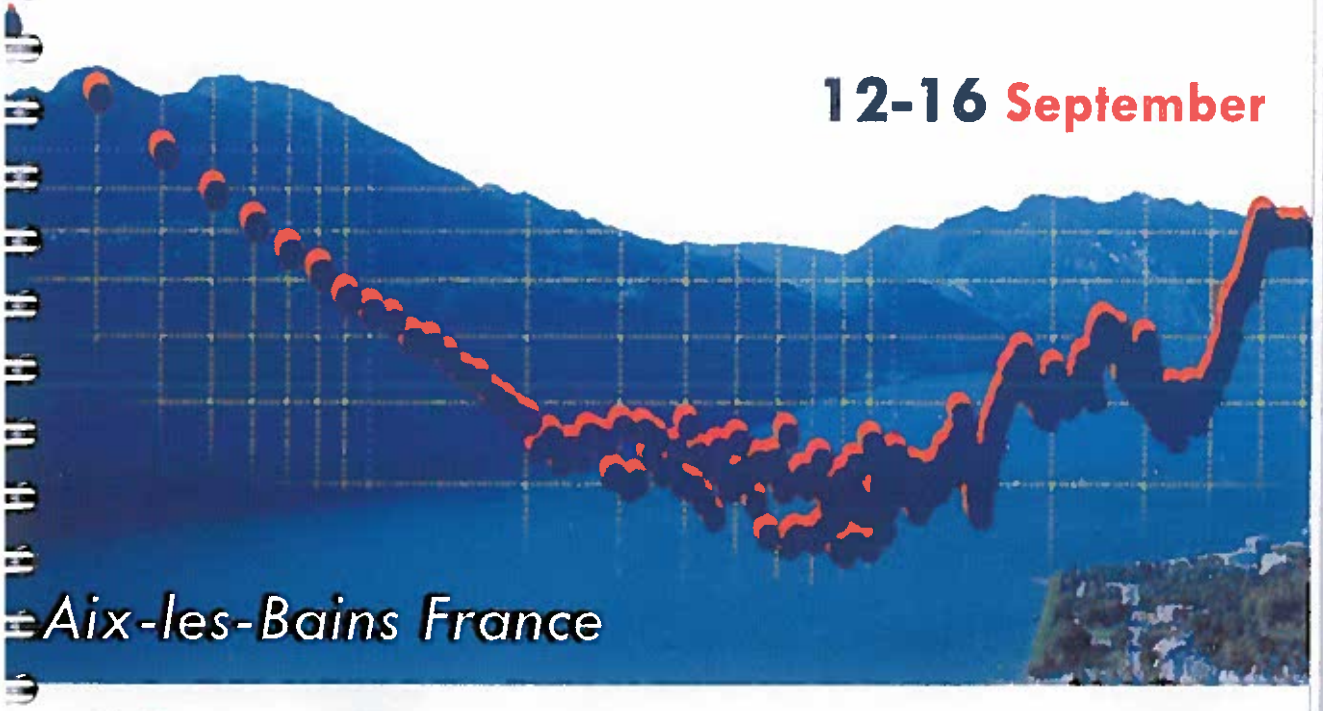

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Quantum cascade detectors and monolithically integrated sensing devices

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Mid-infrared spectroscopy is a reliable method for the identification of gaseous and liquid mixtures due to their unique and inherent absorption spectra. We used a specially designed intersubband material working as laser for a given bias voltage and as a detector without any bias. By the use of such a bi-functional quantum cascade structure material for the light sources and detectors the realization of mid infrared on-chip sensors is possible [1].

Monolithic integration allows for miniaturization and is especially suited for portable devices. This talk aims to give a short introduction in the field of intersubband bi-functional materials with a strong focus on quantum cascade lasers and quantum cascade detectors. The first sensor elements used multimode Fabry-Perot lasers and broadband detector materials [2].

Liquid sensing at room temperature with a monolithic integrated sensor was achieved [2] by a Quantum Cascade Laser (QCL), a dielectric loaded Surface Plasmon Polariton (SPP) waveguide as interaction section of the infrared light with the liquid, and a Quantum Cascade Detector (QCD). As SPP waveguide structures gold layers with SiN dielectrics, reduce the losses and allow long distance guiding of the mid-infrared light.

To further improve the sensitivity and selectivity of these monolithically integrated mid-infrared sensors we utilized distributed feedback quantum cascade lasers. Weakly coupled DFB quantum cascade lasers emit single mode mid-infrared light. RT laser threshold current density of the first demonstrated devices is around 3 kA/cm^2, a pulsed output power in the range of 200 mW was measured [3].

To show gas sensing a distributed feedback ring quantum cascade laser can be integrated with a detector element. The surface operation mode enables for comparable long interaction lengths as needed for gas absorption measurements. By placing a single pass gas-cell into the beam path gas concentrations from 0% up to 95% of butane and 0% up to 60% of propane in nitrogen were measured with a sensitivity in the low percent range [4].

References:

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