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Abstract Book

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(MOLEC-OD1) New Components and Systems for Mid-IR Sensing

(MOLEC-OD1.1) Mid-infrared supercontinuum lasers – a powerful new tool for vibrational spectroscopy

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Supercontinuum lasers (SCL) have been rapidly progressing into the mid-infrared spectral region in recent years. Due to their unique properties they open up new possibilities for laser-based mid-infrared spectroscopy in many areas. SCLs unite high brightness and spatial coherence with extremely broadband spectral coverage in the mid-infrared spectral region up to 16 µm wavelength, achieved by a single device. Thereby, they exceed thermal sources and even challenge quantum cascade lasers, as SCLs also cover the spectral range around 3 µm, where powerful quantum cascade lasers lack broader availability. In this contribution we present an overview of the currently available hardware and its analytical possibilities in mid-infrared spectroscopy. Initial limitations imposed by high intensity noise levels of SCLs have been overcome in the meantime, paving the way for their use in demanding applications. Selected experimental results obtained with commercially available SCLs in different measurement configurations are shown. Among them chemical detection of an explosive precursor at standoff distances and diffraction-limited chemical mapping of polymer films and red blood cells in reflection geometry. Furthermore, we introduce this advanced light source as a replacement for conventional thermal emitters in a Fourier Transform Infrared (FTIR) spectrometer. The analytical performance of the SCL based FTIR spectrometer was tested and compared with its conventional configuration employing a thermal emitter. The obtained results show a four-times-enhanced detection limit due to the extended path length enabled by the high brightness of the laser.

(MOLEC-OD1.2) Towards In-situ Measurements Of The Protein Secondary Structure Based On Mid-IR Lab-on-a-chip Quantum Cascade Technology

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The rise of quantum cascade technology led to novel concepts and devices for chemical sensing in the mid-IR spectral region. Especially, the invention of quantum cascade lasers (QCLs) in 1994 [1] sparked a complete new field of research, investigating this new type of optoelectronic devices and their applications. After more than two decades, QCLs and their counterpart, the quantum cascade detector (QCD), can be designed to address any wavelength between 3 – 12 µm while showing high performance operation. This allows e.g. tailoring suitable single-mode emitting devices addressing the strong fundamental absorption features of most molecules [2]. Nowadays, especially the field of liquid sensing has attracted much attention. This is due to significant QC device improvements, which e.g. allows the measurement of protein secondary structures in aqueous solution, outperforming state-of-the-art bulky FTIR-systems [3]. In addition, novel devices developed in our lab support same-wavelength emitting and detecting active regions, paving the road towards monolithically integrated lab-on-chip sensors [4]. In this work, we present the detection of changes in the secondary structure of Bovine Serum Albumin (BSA), when using such type of monolithic devices. By carefully designing the active region and on-chip connecting QCL and QCD via a plasmonic waveguide, we can realize highly sensitive and versatile lab-on-a-chip devices. Their key features are a very small footprint (~25 mm3), with a small and tailorable, but still highly sensitive, interaction section, suitable for microliter scale liquid detection. We present two types of experiments: a) measuring residual water concentrations in isopropyl alcohol within a homemade microfluidic cell (~60 µl probe volume) or in-situ. And b) the analysis of temperature-induced changes in the secondary structure of BSA. The later experiment is performed in-situ by submerging our chip into the liquid. This shows the robustness and suitability of our devices for in- and on-line measurements, where only small probe volumes are available, contrasting sampling techniques, including their delayed response. [1] Faist et al., Science 264, 553-556, 1994. [2] Szedlak et al., Opt. Engineering 57, 011005, 2018. [3] Schwaighofer et al., Sci. Rep. 6, 33556, 2016. [4] Schwarz et al., Nat. Commun. 5, 4085, 2014.

(MOLEC-OD1.3) Broadband Integrated Waveguide Sensor for trace analysis in the fingerprint Mid-IR range

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Advances in mid-IR sources, detectors and integrated photonic circuits (PIC's) allow the design and fabrication of novel, highly integrated sensor systems. In this contribution we present a sensing platform for mid-IR laser spectrometers based on novel Germanium-on-Silicon waveguides incorporating dedicated optics for coupling the laser beam in and out of the PIC. Opposed to classical ATR systems, the light interaction in the PIC takes place over the whole length of the waveguide in contact with the sample, leading to higher effective path lengths and thus to potentially higher sensitivities. Furthermore, to enrich the analyte in the evanescent region, the Germanium-on-Silicon waveguides were coated with a well defined and chemically modified mesoporous silica. By means of micro-lenses etched on the Si