08.30-10.30 CWE - Novel Components and Devices

Presider: B. Culshaw, *Strathcylde University, Glasgow, UK* **GALA**

08.30 CWE1 (Invited)

Novel Gas Sensor Based On Difference Frequency Mixing Using All Fiber Beam Delivery

D.G. Lancaster, R.F. Curl, F.K. Tittel
Rice Quantum Institute, Rice University, 6100 Main St., Houston, TX 77005-1892, USA.

L. Goldberg, J.Koplow
Optical Sciences Division, Naval Research Laboratory, Washington, D.C. 20375-5672, USA.

Tunable infrared laser absorption spectroscopy has proven to be a powerful technique for accurately determining the real time concentrations of trace pollutants in both point monitoring and open path configurations (1). For the detection of molecules including many of the common pollutants, and most of the hydrocarbons, the key spectral region for absorption spectroscopy is in the mid-infrared (3-5 μm).

In this paper we report a new infrared, narrowband spectroscopic source based on difference frequency generation (DFG) in periodically poled lithium niobate (PPLN). Up to 1 μW of light has been generated which is tunable from 3.85 to 4.3 μm. The system is pumped by a 16 mW fiber coupled external cavity diode laser (ECDL) with a tuning range of 845 to 865 nm and a Yb fiber amplifier which is seeded by a single longitudinal mode 1083 nm DBR diode. Advantages include fiber beam delivery which improves system robustness by reducing the quantity of bulk optics used and the use of a wavelength division multiplexer (WDM) for combining the pump beams which ensures automatic overlap and mode matching in the non-linear crystal. Furthermore, the system uses a compact and efficient diode-pumped fiber amplifier.

The Yb-doped fiber amplifier utilized a 7.2 m long double cladding fiber, and was side-pumped with a 970 nm broad stripe diode using a v-groove pump coupling technique [2]. All amplifier components were packaged into a 9 x11x2 cm housing. When seeded at 1083 nm with 30 mW coupled from a 50 mW DBR laser diode, the amplifier generated a maximum saturated output power of 780 mW. Due to a very high small signal gain G_s~50 dB, more than 90% of this maximum power could be extraced when the amplifier was seeded with only 1 mW. The ECDL was isolated from feedback using two opto-isolators, prior to coupling into a single longitudinal mode (SLM) fiber. The DBR seed diode was isolated from the Yb fiber amplifier feedback using a single opto-isolator. The amplifier seed beam was then collimated with a cylindrical lens and also coupled to a SLM fiber. Polarization controllers attached to the fibers were used to set the polarization for both the pump and signal beams. The two fiber coupled sources were combined into a single SLM fiber using a fiber WDM. A single lens (f=10 mm) was used to image the beam spot from the output fiber end onto the PPLN with a magnification of 7.5. The mid-infrared DFG output was collimated by a 50 mm focal length CaF_2 lens and an AR coated Ge filter was used to block the residual pump beams. A calibrated thermo-electrically cooled HgCdTe detector was used to measure the generated infrared beam power and monitor trace gas absorptions.

To demonstrate the suitability and bandwidth of this source for trace gas detection, spectral scans of calibrated mixtures of 0.97 ppm CO_2 (~2380 cm^{-1}) and 1.0 ppm N_2O (~2560 cm^{-1}) were carried out in a 18 m pathlength multi-pass cell.

In conclusion, a potentially compact and robust fiber coupled DFG-based mid-infrared spectroscopic source has been demonstrated that uses a tunable ECDL and a 1083 nm SLM diode seeded Yb-doped fiber amplifier. This system currently uses bulk quasiphasematched PPLN, but lends itself to using recently reported nonlinear optical waveguide materials for significantly increased conversion efficiences.

References:

(1) "Room-temperature mid-infrared laser sensor for trace gas detection", Thomas Töpfer, Konstantin P. Petrov, Yasuharu Mine, Dieter Jundt, Robert F. Curl and Frank K. Tittel, Appl. Opt. 36, 8042-8049, 1997.

(2)"V-groove side-pumped 1.5 μm fibre amplifier", L.Goldberg, B.Cole, E. Snitzer, Electr. Lett., 33, 2127-2129, 1997.