PUBLISHABLE EXECUTIVE SUMMARY (PERIOD 1)

Recent demonstrations of tunable infrared laser sources based on novel nonlinear optical materials have largely renewed the interest for vibrational molecular spectroscopy. Specific absorption features in the mid-infrared (MIR) range of the spectrum are indeed recognized as a powerful and often unique way to provide high sensitivity detection and identification of a large array of molecules. This is particularly relevant in the gas phase in order to avoid preconditioning steps associated with other detection methods (wet chemistry, gas chromatography, mass spectroscopy). Yet, many promising results have remained confined to laboratories for lack of suitable MIR sources, leaving complex Fourier-Transform spectrometers as the only alternative.

To promote direct MIR spectroscopy as a competitive solution for gas analysis, the main technical and scientific objective of the VILLAGE project is the development of a cost-effective widely tunable MIR laser source of high spectral purity. As shown in the Figure 1, this source will combine a 2 µm Thulium (Tm)-doped fibre laser device including a widely tunable Bragg grating stage, a nonlinear frequency converting semiconductor crystal (Orientation-Patterned Gallium Arsenide) and a high spectral purity optical parametric oscillator (OPO) cavity.

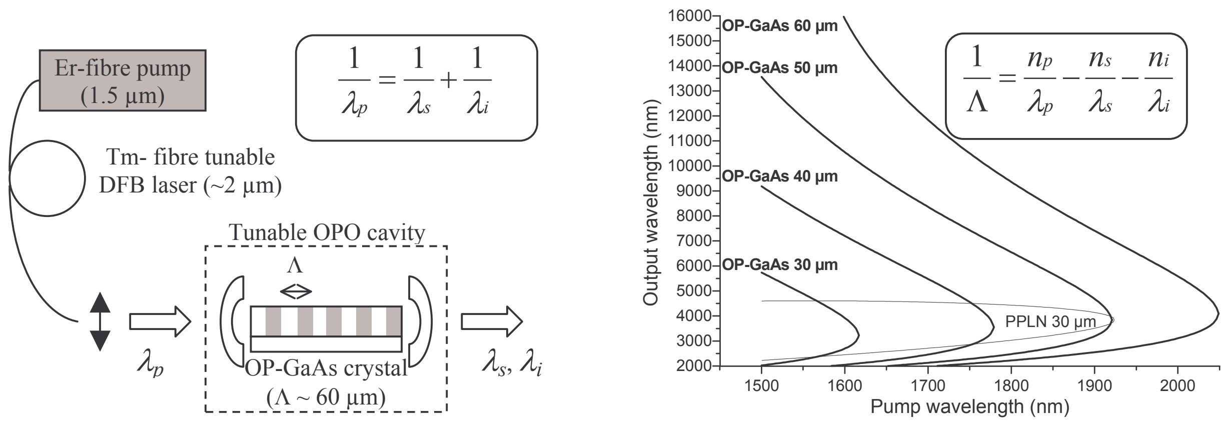

Figure 1 : a) Village source concept (left). b) Typical tuning curves (right).
Insets : key equations linking pump, signal and idler wavelengths, indices and QPM period.

Such a design has the potential for unprecedented performance in terms of both primary specifications and suitability to target multigas analysis of main pollutants generated by and emitted from industrial processes and more specifically of the gases believed to contribute to global warming. As described below, a simplified version of this tunable MIR source has been planned at the end of first year of the three year project duration. As a second objective and in parallel with further refinements, the MIR source will be integrated into a transportable gas sensing spectroscopic instrument for demonstration through practical tests that the system is capable of analyzing the target gas mixtures at specified concentration levels. Those levels are expected to be in the part per million to trillion range, depending on gas options and laboratory or onsite-based campaigns, according to a validation strategy chosen thanks to a dedicated exploitation-oriented task.

This approach will enable early promotion of the project results to several other growing instrumentation markets such as food, security and health-related applications. It is also suited to efficient evaluation of VILLAGE scientific and technological choices compared to the state-of-the-art in infrared spectroscopy.

In agreement with the work plan, the first twelve months of the project have enabled the consortium to specify and fabricate, with several characteristics exceeding expectations, all the subparts needed to implement a first version of MIR tunable source that will provide useful feedback to the design of the targeted spectrometer. The corresponding technical achievements and dissemination paths include to date:

- Under Work Package 1 (Fiber laser source):

  - The fabrication of prototype Tm-doped fibres with high Tm concentration (~ 1 wt.%) and with germanium doping to provide sufficient photosensitivity for UV writing of in-fibre Bragg gratings.
  - The demonstration of a narrow-linewidth Tm-doped DFB fibre lasers at 1935 nm and 1943 nm with output power > 0.3 W, recently scaled to ~ 1 W. This is the highest output power so far reported for a Tm-doped DFB laser operating in this wavelength regime.
  - The demonstration of a simple Tm fibre laser with ~5 W output power in the 1880-1885 nm band for ~ 6.8W of absorbed pump power at 1565 nm and with slope efficiency with respect to absorbed pump power (~78%) very close to the theoretical limit of 83%.
  - The preliminary demonstration of a gain-switched Tm fibre laser with a peak power of 45 W.

- Under Work Package 2 (Patterned GaAs samples):

  - The delivery of a sample grown before the project start for an early DFG experiment around 3 μm.
  - The design, fabrication and delivery of a new sample exceeding Month 9 expectations in terms of propagation losses and geometrical characteristics, suited to DFG around 8 μm
  - The microscopic characterizations of various samples to validate a growth model.

- Under Work Package 3 (MIR tunable source):

  - The selection of interference-free absorption lines by software supported simulations in the wavelength range from 4 μm to 14 μm.
  - The choice of test gases and wavelengths for the design of the first DFG experiment and study of consequences in terms of pumping wavelength and GaAs crystal period.
  - The implementation of a preliminary DFG experiment around 3 μm and of the planned DFG source around 8 μm.

- Under Work Package 4 (Spectrometric sensor):

  - The training of the consortium members to key features of automatic single line spectroscopy so that the relevant partners can plan the design and characterization steps for each subpart of the tunable MIR sources at the core of the targeted spectrometers.

- Under Work Package 5 (Dissemination and exploitation):

  - The design and launch of the project website http://www.neo.no/village/.
  - The presentation of the VILLAGE concept at the Annual Meeting of the German Physical Society, AMOP section (atomic, molecular and plasma physics), 19 – 23 March 2007 in Düsseldorf (S. Vasilyev *et. al.*: “Development of mid-IR CW narrowband 5 – 15 μm tunable laser source for molecular spectroscopy“).
  - A paper submission on Tm-fiber laser work, that will be presented at the “Bragg Gratings, Photosensitivity and Poling in Glass Waveguides” (BGPP) OSA meeting in September (2007) in Quebec, Canada (D. Y. Shen *et. al.*, “Thulium-Doped Distributed-Feedback Fibre Laser with > 0.3 W Output at 1935 nm”).