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FIRST STEPS OF MATURATION TOWARDS SPACE OF NESTED CAVITY OPTICAL PARAMETRIC OSCILLATOR AND AMPLIFIERS FOR DIAL BASED ON PERIODICALLY POLED NONLINEAR MATERIALS

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ABSTRACT

We report on the first steps of maturation towards space of a nested cavity optical parametric oscillator and amplifiers, based on periodically poled nonlinear materials, emitting in the 2 μ m range for multi species differential absorption lidar (DIAL).

1. INTRODUCTION

Emitter and detectors technologies, for future spaceborne DIAL instruments for monitoring of the main green-house gases, have been the subject of several developments over the last decades. As far as the emitter is concerned, developments of bulk solid state laser sources, fiber laser sources, parametric sources have been actively pursued, including in the frame of the first DIAL spaceborne mission, MERLIN [1-5].

Here, we report on the results obtained in the frame of GENUIN (for Generic Frequency Converter Unit for Spaceborne Lidar Instruments) ESA Technical Readiness Program. In this study, we worked on the first steps of maturation towards space of a nested cavity optical parametric oscillator and amplifiers, based on periodically poled non-linear materials, emitting in the 2 μ m range for multi species DIAL.

Indeed, a few years ago, we began to work on the development of a generic instrument dedicated to the DIAL measurement of the three major greenhouse gases (CO₂, H₂O, CH₄) with a single instrument based on a single versatile emitting device [6]. In the prospect of future space

missions, it shows high promises since 1/ such amplified optical parametric oscillator scheme can benefit from the latest developments of 1 μ m lasers for space, for which the maturation process was difficult [7], 2/ a mission targeting several species (for instance both CO₂ and H₂O ...) can be envisioned, 3/ a single spatialization process of the emitter for different missions dedicated to different gas measurements (CO₂, CH₄, H₂O) can be performed. Such capability is offered by the combination of i) the injection-free nested cavity optical parametric oscillator architecture, and ii) the periodically poled materials properties allowing frequency tuning by temperature change rather than angle tuning in classical birefringence phase matched non-linear materials.

We detail in this paper the first opto-mechanical design for the NesCOPO, which was realized taking into account the specifications for space operation, and on which preliminary vibration testing was performed, and the overall amplified NesCOPO performances, while pumped by a 100mJ laser. Radiation testing results on the specifically developed rubidium doped, periodically poled KTP crystals are also presented.

2. METHODOLOGY

2.1 The GENUIN emitter architecture

The emitter set-up is depicted in Fig.1.

The pump laser used here is a high energy (100 mJ), 30 Hz, commercial single frequency Nd:YAG laser, delivering 12 ns pulses. In this work, the goal was not to work on the pump laser

itself, given the work perform in the frame of other projects for spaceborne 1 μ m lasers.

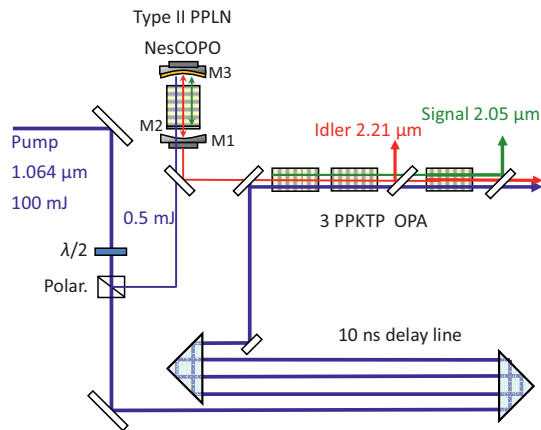


Fig. 1. GENUIN emitter optical layout.

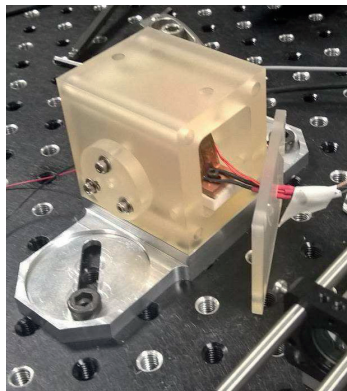


Fig. 2. GENUIN NesCOPO picture.

GENUIN NesCOPO, depicted in Fig.2., is realized in zerodur glass material. The copper crystal oven shape was optimized through thermomechanical modelling, and heated via a Kapton encapsulated resistor. The NesCOPO is pumped by 0.5 mJ. The remaining pump energy is delayed to optimize the temporal OPO output with the pump pulse with amplifier stage, composed of three Rb:PPKTP crystals of 12mm length. A filtering element placed between crystals 2 and 3 avoids saturation of the amplifiers.

2.2 GENUIN amplifier non linear crystals

The non linear crystals are high aperture (5x7 mm²) Rb:PPKTP crystals specifically developed for this project. They were exposed to gamma radiation, and tested in terms of transmission and poling period structuration, as detailed in [8].

3. GENUIN emitter main performances

The NesCOPO crystal temperature was set as to emit a single frequency signal wavelength in the 2.05 μ m range. With a single poling period, at a given temperature, it is possible to address both the CO₂ R30 line and the adjacent H₂O line. The 2.06 μ m H₂O line can be targeted by elevating the crystal temperature of around 15°C. The methane 2.29 μ m line can be addressed by using an adjacent poling period of the NesCOPO crystal and the same mirrors as shown in [5]. Given the chosen opto-mechanical set-up, translation of the crystal in the cavity was not implemented here. However, given the NesCOPO low oscillation threshold, an additional NesCOPO targeting methane could be added.

We managed to generate up to 10,7 mJ of signal only, at 2.05 μ m, and measured an amplifier conversion efficiency of 37% towards signal plus idler (i.e. a 19,8% conversion efficiency towards signal alone). Addition of another crystal could increase again the conversion efficiency, or reducing the pump beam (with the potential damage risk).

Preliminary vibration testing was performed using a vibration pod available in our lab, with the applied acceleration described in Fig.3

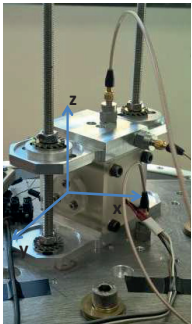
	Test	Description
	SIN2.5	2.5 g accelerations will be applied from 75 to 140 Hz, rate : 2 octaves / minute along vertical axis
	SIN10	10 g accelerations will be applied from 20 to 75 Hz rate : 2 octaves / minute along vertical axis
	RAND	Random vibration test with the level profile described in TN4, Along vertical axis, for 2 min.

Fig. 3. GENUIN NesCOPO on the vibration pod and applied levels

Additional details will be given concerning the frequency stability, tuning procedure, and perspectives for more energy output with pumping with a higher energy laser.

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