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CONDUCTION COOLED COMPACT LASER FOR THE SUPERCAM LIBS-RAMAN INSTRUMENT

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ABSTRACT

A new conduction cooled compact laser for SuperCam LIBS-RAMAN instrument aboard Mars 2020 Rover is presented. An oscillator generates 30mJ at 1µm with a good spatial quality. A Second Harmonic Generator (SHG) at the oscillator output generates 15 mJ at 532 nm. A RTP electro-optical switch, between the oscillator and SHG, allows the operation mode selection (LIBS or RAMAN). Qualification model of this laser has been built and characterised. Environmental testing of this model is also reported.

I. INTRODUCTION

This communication describes a conduction cooled diode pumped solid state laser for SuperCam instrument [1] aboard Mars 2020 rover. The Qualification Model (QM), representative of the flight model, has been built and tested. It is a compact laser, designed to perform in burst mode to acquire laser induced breakdown spectroscopy at 1064 nm and RAMAN analyses at 532 nm. This laser requires no active cooling, neither for the laser diode nor for the laser medium.

II. LASER ARCHITECTURE AND PERFORMANCE DATA

Fig. 1 shows a picture of the laser QM. Due to the mission constraints, compactness and weight were two driving factors of the mechanical design, keeping the necessary stiffness at the same time. Laser dimensions are about ϕ55 x 230 mm and weight is about 550 g.

The laser is operated in the nanosecond regime, at a repetition rate of 10Hz maximum. Its architecture is based on a single oscillator followed by a Second Harmonic Generator. The oscillator is designed to provide a high beam quality.

A. The oscillator

The oscillator provides the high beam quality and short pulse length needed for LIBS analysis. It is based on a Nd : YAG rod longitudinally pumped by a multicolor stack, insuring pump absorption over large temperature range. This allows both the diode and the rod to be conductively cooled and operated on large temperature range. The oscillator is Q-switched with a RTP Pockels cell to produce nanosecond pulses.

Oscillator is linear, closed on one side by the HR coated rod side and by the outpout coupler on the other side. Reflectivity of the outpout coupler is 40%. A polarizer, wave-plate and Pockels cell Q-switch are inside the cavity. The oscillator provides an output energy of about 30mJ at 1 µm with a pulse duration < 5ns and a beam quality factor < 3.

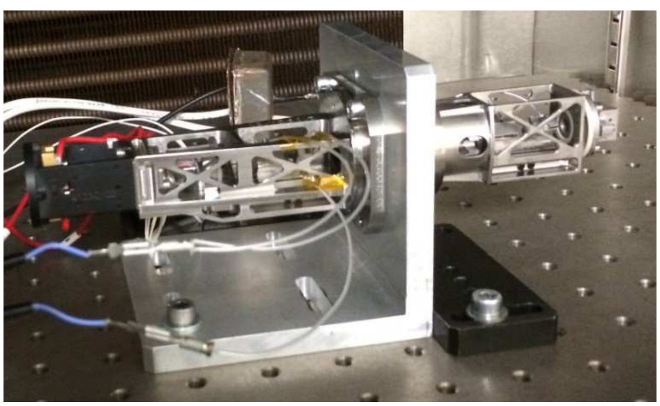

Fig. 1. Picture of the laser QM

B. Commutator and Second Harmonic Generator

A KTP Second Harmonic Generator (SHG), placed at the output of the oscillator, produces the 532 nm beam used in Raman mode. A conversion efficiency of about 50% is obtained at 532 nm. A RTP electro-optical switch, between the oscillator and SHG, allows the operation mode selection (LIBS or RAMAN). In the absence of high voltage, infrared beam at 1064 nm is emitted. When the high voltage is applied to the RTP Q-switch, 1064 nm and 532 nm beams are both emitted.

D. Environmental testing

The laser has been placed in a climatic chamber for temperature testing. Temperature tests were performed for a 1064nm output energy of 30mJ at ambient (see Fig. 2). Energy remains over 24mJ when temperature changes between -50°C and 20°C. Pulse duration is about 4ns on the same temperature range. As stated before, these results have been obtained with a completely passively cooled laser, without temperature control neither on the pump diode nor on the Nd : YAG crystal. Absence of temperature control drastically reduces electrical consumption of the laser (less than 2 W).

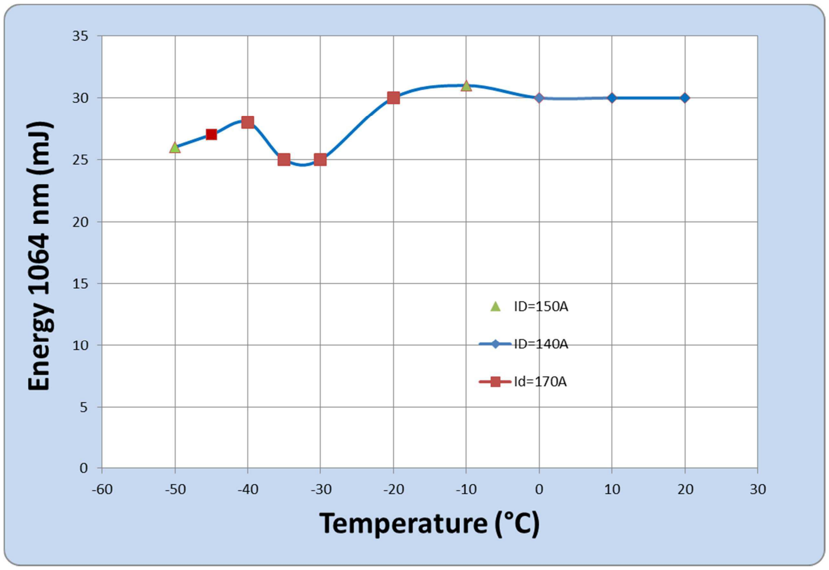

Fig. 2. Energy at 1064 nm versus laser temperature

Fig. 3 shows the energy at 532 nm (residual beam at 1064 nm was eliminated with dichroïc mirrors for characterization) versus laser temperature. Energy remains over 12mJ when temperature changes between -30°C and 10°C. The heater on the SHG crystal mount should be activated to keep phase matching at low temperature (T < -20°C).

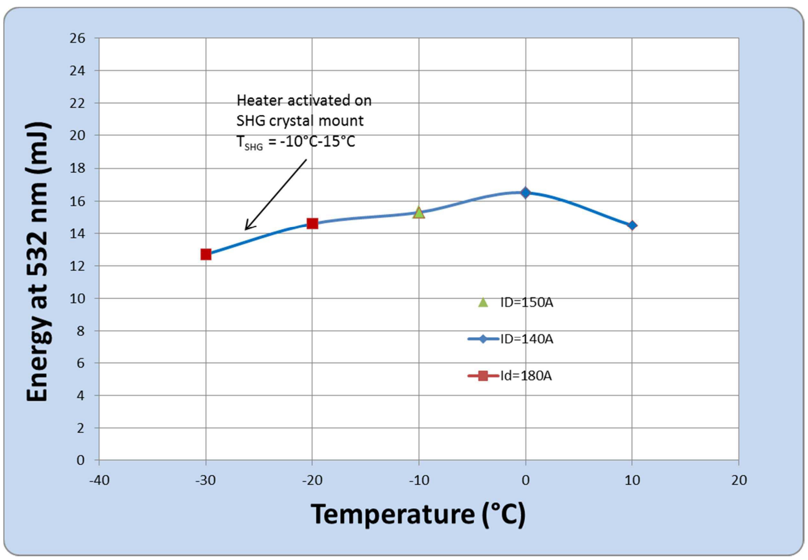

Fig. 3. Energy at 532 nm versus laser temperature

The QM laser will be tested in vibrations and shocks during qualification, with vibrations as high as 28 gRMS and shocks as high as 800g. During vibrations and shocks the laser is non-operational.

SuperCam laser is based on ChemCam laser aboard the rover Curiosity, on Mars planet since August 2012. The integration processes have been re-used to benefit from Chemcam heritage. For example, Supercam laser is sealed by laser welding of the titanium covers. This insures the long term reliability needed for spatial laser.

SuperCam laser provides in a volume similar to ChemCam laser, the same laser performances in LIBS mode at 1 µm and the new performances for Raman mode at 532 nm.

REFERENCES

[1] Perez R. et al., “The SuperCam instrument on the Nasa MARS2020 mission – optical design and performance”, ICSO 2016, in press.

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