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Raman Laer Spectrometer Development for ExoMars

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Abstract

The Raman Laser Spectrometer is one of the Pasteur Payload instruments, within the ESA's ExoMars mission. The aim of the work presented here is to provide a summary of the instrument design and performances. For that the instrument current characteristics and performances, and its technological ass assessment program main results are presented and discussed.

1. Introduction

Raman Spectroscopy is a powerful tool for the structural and compositional analysis of a substance either in the solid, liquid or gas state.

The Raman Laser Spectrometer (RLS) is part of Pasteur payload inside ExoMars mission and it is being developed by an European Consortium composed by Spanish, French, German and UK partners. In the present configuration of the Exomars rover the instrument consist in an only Raman technique operating inside the analytical laboratory. An optical head connected by optical fibres with the laser and the spectrometer will analyze the crushed samples obtained by the drill system.

2. Instrument Functional description

The RLS has been designed under a modularity concept: three units connected by means of electrical and optical harness. This configuration provides flexibility for being accommodated.

The RLS flight segment is composed by the following units (see Figure 1 and 2):

- SPU Spectrometer Unit, based on transmission optics, which includes active cooling for CCD temperature control by means of a TEC device.
- IOH, Internal Optical Head, which focuses the laser signal on to the sample by means of an autofocus system and collects the Raman signal to be analysed in the spectrometer.
- ICEU Instrument Control and Excitation Unit, including the power converter, the CCD readout electronics, the instrument processor and the excitation laser

Others: Electrical and optical harness, software and the calibration target.

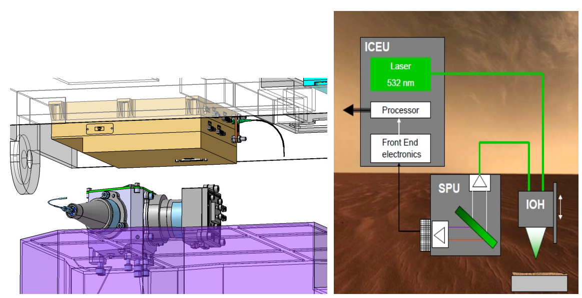

Figure 1 and 2. RLS SPU and ICEU configuration on ExoMars ALD and RLS Functional scheme

The RLS working flow consists in the following main steps (see Figure 1):

- the powdered sample is illuminated by means of the IOH optics, with the laser light coming (through the excitation fiber) from the laser located in the ICEU.
- The Raman signal obtained is properly filtered and delivered by the IOH (through the reception fiber) to the SPU.
- At the SPU the Raman signals are analysed by a transmission diffraction grating and registered in the CCD.
- The obtained image is sent to the ICEU FEE (Front End Electronics) and processed

instrument processor electronics, previous prior to be sent to the Rover OBDH.

3. Instrument detection capabilities

The Raman spectra (number of peaks, positions and relative intensities) , are determined by the structural symmetry and elementary composition of the molecules. Therefore, by analysis of Raman spectral pattern and detailed peak positions, phase identification and chemical characterization of the samples can be made. The spectrometer is designed to covers all these vibrations and with enough spectral resolution allowing distinction between substances with similar structure and small chemical compositional differences.

4. RLS Instrument characteristics and performances

The RSL for Exomars has been developed under a modularity concept. It has been designed to provide its full performances in an operative thermal environment of between 0ºC and -40ºC (±10ºC of margin in both sides). Main characteristics and performances are as follows:

- Laser excitation wavelength: 532 nm
- Irradiance on sample: 0.8– 1.2 kW/cm2
- Spectral range: 150-3800 cm-1
- Spectral resolution: 6 cm-1 lower spectral wavenumbers; 8 cm-1 long spectral wavenumbers, and spectral accuracy < 1 cm-1
- Spot size: 50 microns, through an optical fiber of 50 microns core.
- Active focussing of Laser excitation signal onto the sample (powder) of ±1mm range and 2 µm resolution
- Mass ~ 2.4 kg and power consumption between 20W and 30 W (depending on the temperature range and operational mode).

5. Technological Readiness Status

Along the past years RLS Team has performed in parallel a technology development program in order achieve a TRL5. The program was stated an executed following a bottom-top approach, i.e. starting for the validation from critical components, material and processes, and concluded with an end to end instrument breadboard. All the technological risk areas were identified at the early beginning. Components not available as space qualified devices or without enough space heritage or which have not been qualified for the same space environment (temperature, vibration, radiation, etc.) were included as technological risk devices. Validation at this level was performed in relevant environment. As well unit breadboards were developed and tested, and finally integrated in the instrument Breadboard (See Figure 3).

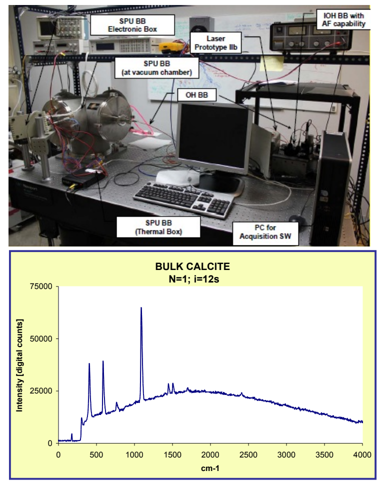

Figure 3. RLS breadboard and a typical Raman spectrum taken on calcite mineral

6. Summary and Conclusions

The RLS is a key tool to achieve ExoMars objectives and its current technological development provides a promising future for being used on other planetary missions as a non-destructive analysis technique.

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