RAMAN LASER SPECTROMETER OPTICAL HEAD.

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Abstract

Raman Laser Spectrometer (RLS) will be the first instrument capable to analyse an out-of-the-Earth subsurface composition through Raman Spectrometry. RLS is part of the ExoMars mission, in the framework of the ESA's Aurora Exploration Programme. The instrument is located inside the Rover at the Analytical Drawer (ALD) and will analyse powdered samples obtained by drilling from the Martian subsurface in order to determine the geochemistry content and elemental composition of the minerals under study.

The instrument is composed by SPU (Spectrometer Unit), iOH (Internal Optical Head), and ICEU (Instrument Control and Excitation Unit), in which is located the laser excitation source.

The Optical Head is in charge of focusing the excitation laser on the samples (excitation path, composed on collimation stage and a filtering stage for laser narrowing), and of collecting the Raman trace emitted by the sample (collection path, composed on collimation and filtering stages). A focusing mechanism with ±600 μm range is included in the iOH for achieving the proper spot size on sample through the 'auto-focus' algorithm.

As typically in Space projects, a set of different models have been developed following stablished instrument models philosophy: bread board (BB), engineering and qualification model (EQM), flight model (FM), and flight spare (FS).

In this work, the optical head last configuration detailed description is reported on, as well as the FM performance in terms of thermal and vacuum test, mechanical test and functional test.

1. Design

In the following lines an explanation of the main common characteristics for the iOH design, in the sense of how the iOH focalizes the excitation laser signal into the sample and collects the Raman emission towards the SPU, can be found.

Excitation path conic lens collimates the incoming light provided by the laser (allocated into the ICEU) through an optical fibre. After being filtered through a laser line filter, this collimated beam is redirected, by a mirror mounted at 45° into the excitation path, to a dichroic filter mounted also at 45° into the collection path. Such a collimated beam coming from the dichroic is focused, through the focusing system, on the sample, located at its focal point. Focuser (Fig. 1) is assembled to a stepper motor providing it a focusing range of ±600μm. The same focusing system collects and collimates the sample's Raman emission and the laser light backscattered by it from the sample towards the collection path. First, the Raman emission pass through the dichroic, except for most of the laser component (532 nm) that is reflected again towards the mirror (for autofocus purposes [1]), and then is filtered by the long pass filter (LPF). Once the Raman emission has been filtered by the filtering stage (dichroic and LPF) the collimation optics located in the collection path focalizes it into the optical fibre which is connected to the SPU (Fig.1).

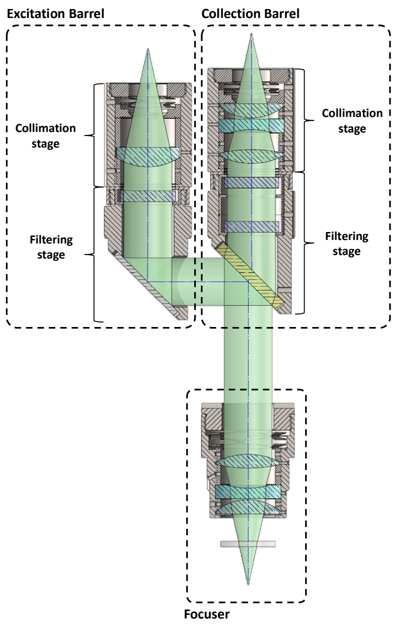

Figure 1.*Optical Head opto-mechanical layout*

2. Assembly and alignment procedure

After a first assembly and having verified the AIV (assembly and integration verification) procedure feasibility, optical elements were mounted and glued into their mounts. Once every single element was assembled, they were mounted onto the upper-housing, under cleaning conditions satisfying the 'Planetary Protection' requirements, following two drivers: the spots (excitation and reception paths) sizes, determining both paths focusing quality, and the spots overlapping, reflecting the alignment between paths optical axes. Table 1 shows the parameters obtained at the end of the FM AIV campaign at the focusing mechanism home position.

Table 1. *FM main features at home position.*

Collection Z size (μm)	53.9 ± 0.8
Collection Y size (μm)	53 ± 1
Excitation Z size (μm)	52.0 ± 0.7
Excitation Y size (μm)	52.2 ± 0.7
Overlapping degree (%)	84.4 ± 0.5

3. Acceptance campaign

After a successful qualification campaign, FM was subjected to an acceptance campaign composed by a mechanical test and a thermal and vacuum test.

A Random vibration test was performed to the iOH FM (acceptance level). The mechanical test objective was to verify whether or not the iOH FM suffered any damages after the application of the mechanical loads defined in Table 2. In addition, unit had to have a stowed first mode frequency greater than 140 Hz.

Table 2. *Random vibration test acceptance level.*

Frequency	In plane	Out of plane
[Hz]	[g2 /Hz]	[g2 /Hz]
20 – 40	+6 dB/oct	+6 dB/oct
40 - 450	0.08019	0.08019
450 - 2000	-6 dB/oct	-6 dB/oct
Overall	7.867 Grms	7.867 Grms

In order to verify that the unit correctly performs under vacuum and thermal working conditions, a thermal and vacuum test (TVT) was performed (acceptance level). The whole test consisted in four thermal cycles at vacuum pressure condition ($P < 10^{-5}$ mbar) being the temperature acceptance levels as is shown in Table 3.

Table 3. *Temperature acceptance levels for the iOH FM TVT.*

	Operative Mode	Non Operative Mode
Maximum (ºC)	+8ºC	+65ºC
Minimum (ºC)	-50ºC	-55ºC

4. Functional test

During acceptance campaign in order to evaluate the iOH performance evolution in different environment conditions, prior and after every test, several functional tests were carried out, consisted on to acquire a set of spectra (RLS calibration target (CT) [1]) at different iOH focusing system positions with respect its home location. For this task a commercial spectrometer (iRaman from BWTEK) was used as well as an external laser source (532 nm Laser from Oxxious). The resultant spectra are shown in Fig. 2, for the following acquisition characteristics: acquisition time, 1250 ms; number of acquisitions, 5; laser power (at iOH entrance), ≈ 30mW. Main values to be pointed out are the Raman maximum peak with respect to the laser trace ratio (≈ 1.5), and the Raman shift from which spectral analysis could be done (≈ 184 cm^{-1}).

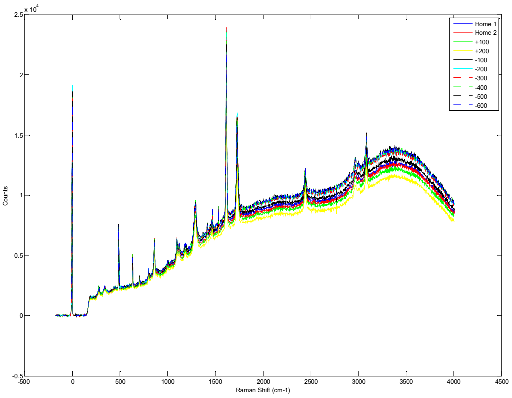

Figure 2. FM after vibration test CT spectra for different focusing positions.

5. Conclusions

ESA's ExoMars RLS iOH FM has been integrated and tested, and the successful results allow to be integrated in the RLS instrument FM.

6. Acknowledgements

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7. References

[1] Fernando Rull; on behalf of the RLS Team, "The Raman Laser Spectrometer for the ExoMars Rover Mission to Mars", *Astrobiology 17, 627-654 (2017).*