EPSC Abstracts,
Vol. 4, EPSC2009-674-1, 2009
European Planetary Science Congress,

WALI - Wide Angle Laser Imaging enhancement to ExoMars PanCam: a system for organics and life detection

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Abstract

A scientifically significant enhancement to the PanCam instrument has been proposed to ESA and STFC for inclusion in the ExoMars payload (baseline and current). The WALI (Wide Angle Laser Imager) consists of two miniature laser diodes operating at 375nm, one with a focusing lens and the other without. PAH organics and possible organic life-form signatures will be searched for using these laser diodes directed primarily at the drill cuttings as they emerge from the drill using the focused WALi. At dusk, horizon scanning can be performed by the unfocused WALi in potential target zones such as crater wall overhangs, cave entrances or rocks with protected shadow zones. The WAC and HRC can both be employed to detect a possible fluorescent signature in the visible portion of the spectrum using the onboard spectral filters of these cameras. In this way, WALI can serve as a triage system for the onboard suite of UREY instruments being employed to detect biochemical markers.

Introduction

One of the primary goals of the ESA ExoMars mission is the detection of signatures associated with extinct or extant life. One other goal is to try to reach a better understanding as to why previous instruments that have landed on Mars and had suitable instrumentation have failed to detect chemical signatures associated with astrophysical and meteoritic observations of the widespread abundance of organics, particularly benzene ring structures known as PAHs (Polycyclic Aromatic Hydrocarbons). PAHs on the Earth are associated with asphalts, fuels, oils, and greases. In our solar system, their presence has been inferred on Titan and in our galaxy they have been observed in inter-stellar dust clouds [1]. Today, the telltale (mid) infrared spectral signature of PAHs and related materials is recognised at all stages of the lifecycle of interstellar matter and it is widely accepted that these species are both abundant and widespread throughout our galaxy and, by inference, in the universe. PAHs are the most abundant form of carbon known in the Universe. Some PAHs are also found in a particular type of meteorities called carbonaceous condrites. It was therefore very surprising when no significant detections were made of PAHs in either the lunar rocks from Apollo or in the regolith sampled by the instruments onboard Viking Landers 1 and 2. This negative result was interpreted as PAHs not being present due to excessive oxidation. PAHs are generally not biomarkers because they can form from abiological carbonaceous matter by free radical buildup or by aromatization of biomarker natural products. Thus, the carbon and deuterium isotope compositions of individual PAH need to be used in conjunction with the presence of alkylated and alicyclic analogues to assign a biogenic or abiogenic origin according to [2].

Laboratory observations of PAH fluorescence

In 2007, laboratory and field experiments were conducted to observe whether fluorescent signatures could be imaged of pure PAH aliquots mixed either in granular peridotite or appearing on the surface of the same rock using a 365nm LED [3]. These experiments were later repeated with a 375nm laser diode on PAH aliquots mixed with granular samples of peridotite as well as crystalline pyrene [4]. They showed that, it is possible to observe similar fluorescent signatures dependent on area and concentration [4]. See the cited reference for further details.

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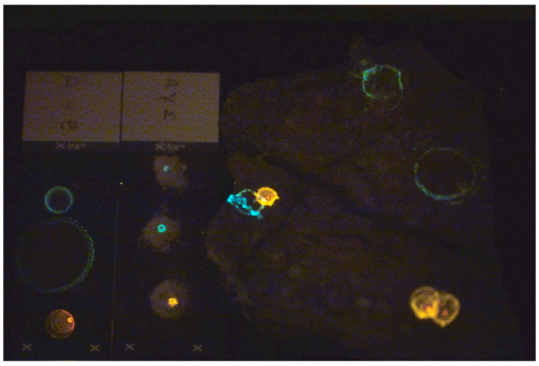

Figure 1 Colour image of fluorescence of liquid PAH (anthracene, pyrene and pyreline) doped on ground Peridotite (left) and on Peridotite rock sample (right).

Laser diode technology for fluorescence

Recently new technologies which allow the miniaturisation of laser diodes at UV wavelengths (intended for the consumer electronics storage market) have appeared which allow complete laser diode systems including lenses to be constructed with masses below 30 grams. Figure 2 shows an example of such a prototype laser diode developed at MSSL and a corresponding control circuit.

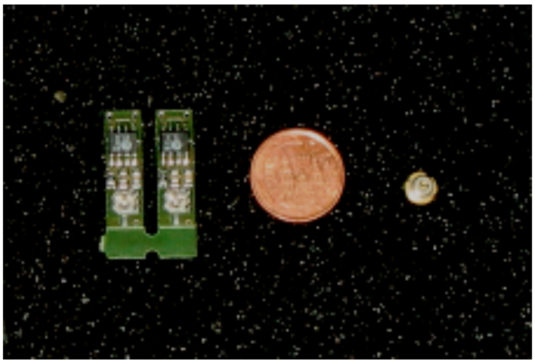

Figure 2. 375nm Nichia UV laser diode (right), integrated control circuitry (left) compared to a 1 UK pence coin for scale (centre).

WALI integrated into ExoMars PanCam

A Nichia® UV 375nm semiconductor laser diode operating with 0.5W of input power was acquired to produce some 20mW of output power in a beam of elliptical shape of 7.5° x 22.5° width. Off the shelf, beam-focusing optics were acquired to reduce this down to a near circular beam to ensure concentration of the laser irradiance into a 5 cm spot projected onto the ground at a distance of 1.7m. The UV laser diode system and control circuitry (see Figure 2) were then tested in a thermal vacuum chamber under Mars-like conditions of temperature and pressure and shown to survive these extremes.

Potential applications

WALI can be easily deployed as part of the PanCam Optical bench with minimum impact on the PanCam instrument, either thermally or electronically. WALI could be employed on ExoMars in daylight conditions for drill cutting PAH detection as well as twilight surveillance.

Acknowledgement

We thank the Director of UCL-MSSL for his continuing support. MCSL thanks the Master and Fellows of Clare College Cambridge and the Harrison Watson Foundation for their ongoing support and encouragement.

Disclaimers

References

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[4] Storrie-Lombardi, M.C., Muller, J.-P. et al., Laser Induced Fluorescence Emission (L.I.F.E.): Searching for Mars Organics with a UV-Enhanced PanCam. Astrobiology J. (in press)