The Mars 2020 Rover features new spectral abilities with its new SuperCam

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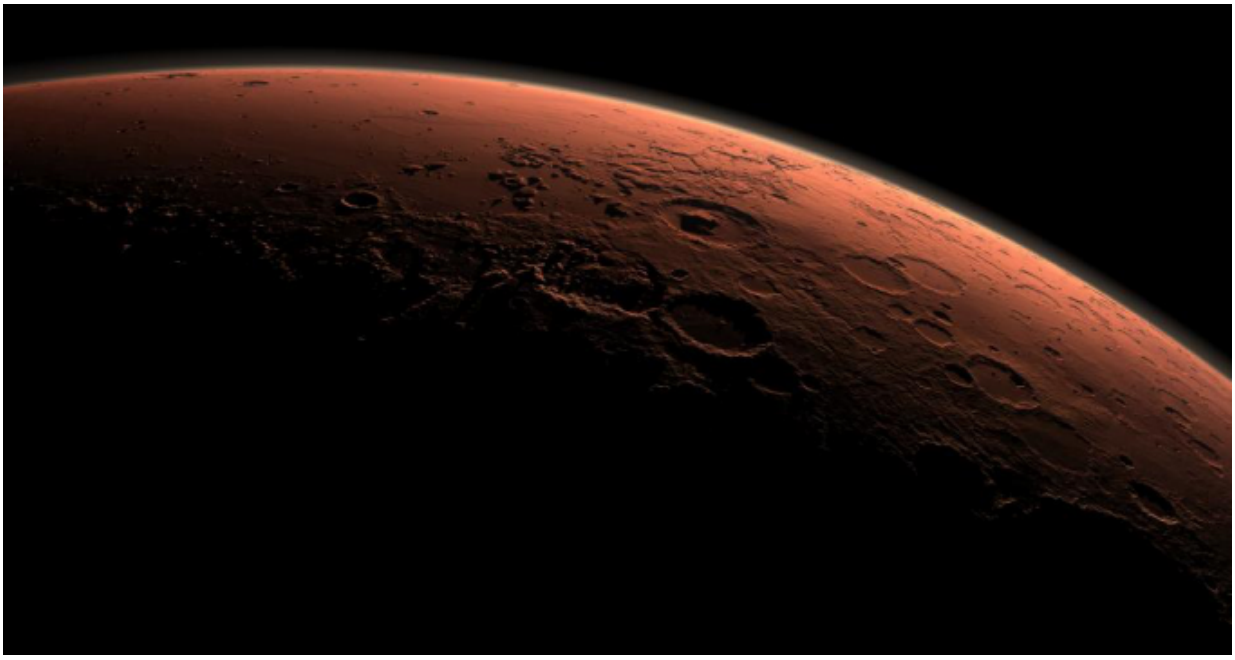

Credit: NASA

As the NASA Curiosity rover roams the surface of Mars, its ChemCam captures the chemical makeup of its surroundings with a specially designed laser system. It is the most powerful laser to operate on the surface of another planet. The burst of infrared light it fires lasts only a few billionths of seconds, but it is powerful enough to vaporize the spot it hits at more than 8,000°C. Even from a distance, the ChemCam can

examines rocks and soil using a process called Laser Induced Breakdown Spectroscopy (LIBS), where laser bursts atomize and excite components and spectral images capture their chemical signatures.

Here on Earth, scientists are already building the next generation's ChemCam with impressive upgrades and brand new spectral capabilities for the NASA Mars 2020 rover, named for the year of its scheduled launch. In addition to a faster LIBS system, the SuperCam will feature an entirely new conduction-cooled laser system to provide the non-destructive analysis ability of RAMAN spectroscopy, capable of detecting carbon-based signatures of organic materials.

Together with the Centre National d'Etudes Spatiales (CNES) and The Research Institute in Astrophysics and Planetology (IRAP), Thales Group is in the final stages of testing the compact SuperCam system that will eventually endure harsh Martian conditions. They have already built and tested a full, representative model, the results of this research will be presented during the OSA Laser Congress, 1-5 October 2017 in Nagoya, Japan.

Unlike Curiosity's LIBS-only functionality, this new instrument will be able to switch between a LIBS mode and a Raman mode of lasing, a method that requires two different laser colors to excite and probe molecular vibration energies for its non-destructive chemical identification. The second color is produced by a crystal that doubles the 1064 nanometer frequency used for LIBS measurements - which now produces 10 times as many shots in each burst of the laser for faster sampling.

This second, 532 nanometer beam will allow Mars 2020 to detect molecular structures evident of organic matter—evidence of past life. The new optical architecture required to produce the two operation modes, however, was not without its challenges.

The upgraded LIBS oscillator uses a diode pumped Nd:YAG crystal, as opposed to ChemCam's Nd:KGW, which provides the longer bursts but requires new methods to ensure functionality over a large temperature range. Because the Nd:YAG absorbs over a narrow range of frequencies to lase at a given temperature, the SuperCam uses a multicolor stacked diode that can pump with a wide spectrum to account for a range in temperatures.

"This laser is running in burst mode, but with this laser we can do 1000 shots in one burst while the ChemCam laser was 10 time less," said Eric Durand, one of SuperCam's developers at Thales Group, France. "We longitudinally pump this laser with a stack which is a broadband emitting so that when the temperature is changing, the ND:YAG crystal is still absorbing the light and the laser can be used over at least 50 to 60 degrees without temperature regulation."

Adding another complication to temperature control, the KTP crystal producing the green, frequency doubled light required additional stabilization.

"The most difficult aspect was to achieve the temperature range also with the green wavelength because we have to keep the efficiency over the whole range, and it was only possible by heating a little the KTP crystal," said Durand.

The temperature stabilization required to keep the system aligned and working for either mode is difficult enough to achieve in a lab, but this system was designed to have the same stability while on the rover as it traverses the rocky Martian terrain. Moreover, it has to meet tight size and weight restrictions that come with space travel and stay free of contaminants that would destroy its components - a feat achieved by sealing the instrument with laser-welding.

The robust and powerful abilities of the new SuperCam will be an invaluable chemical probe for the Mars 2020 rover and may just bring to life a whole host of new findings back to us here on Earth.

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