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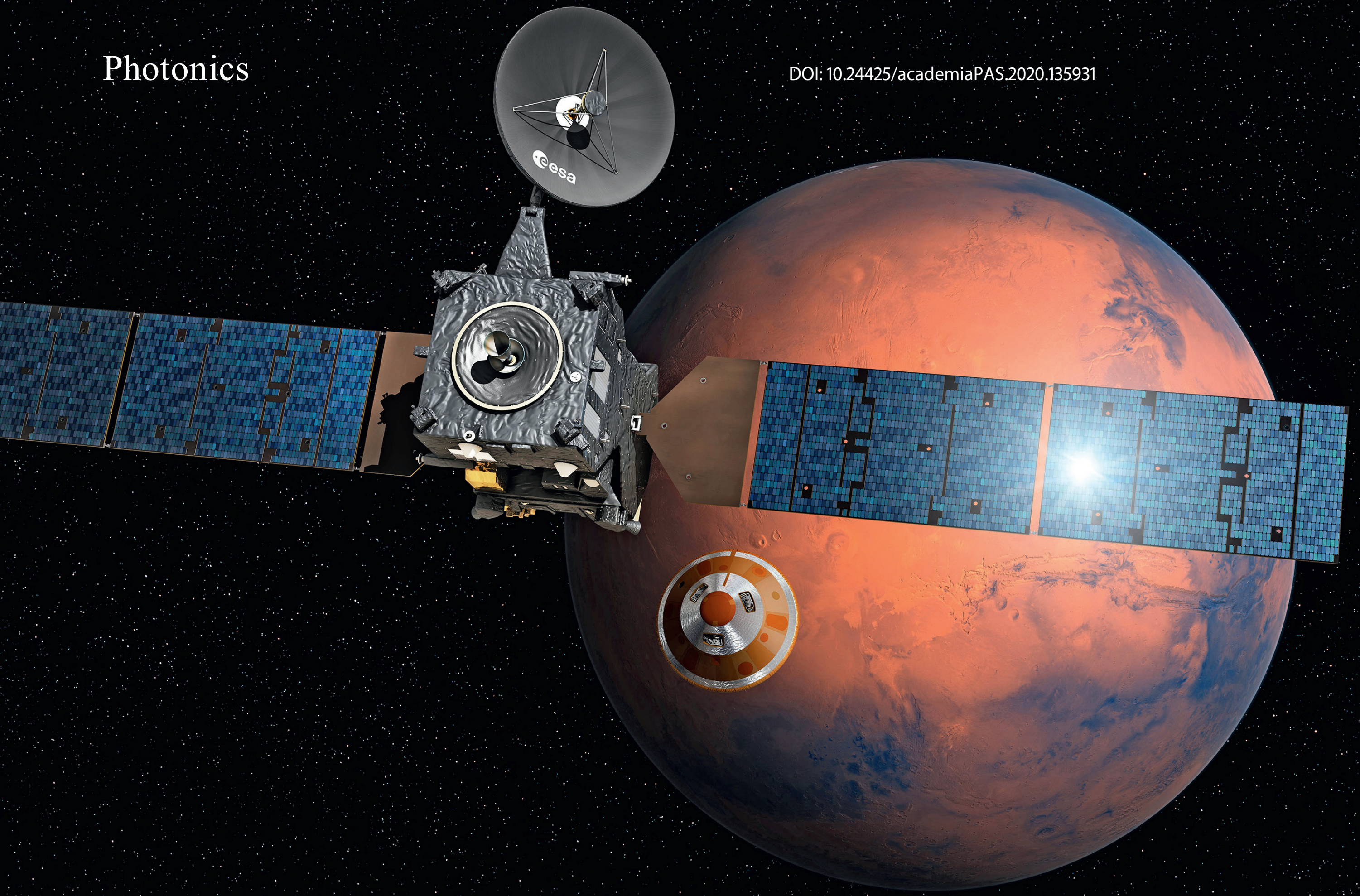


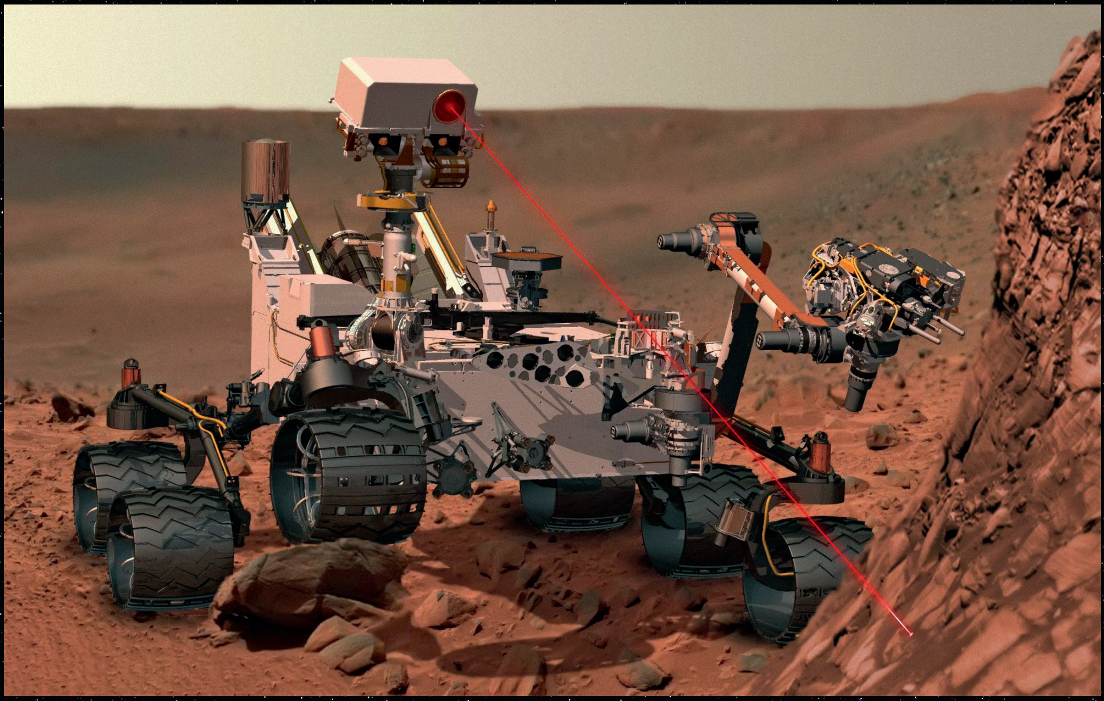
The Schiaparelli lander, sent to Mars as part of the ExoMars mission

Technology in Search of Life

Sensors designed by Polish engineers help detect traces of life beyond Earth. **Adam Piotrowski** of Vigo System tells us what else these devices can do.

The company you lead designed a device that was installed on the Curiosity rover and sent off to Mars. How exactly does this device work? What does it do on the Red Planet?

ADAM PIOTROWSKI: Our company produces various types of semiconductors. The first stage of this process involves growing crystals, which means creating conductive layers that react to light. This is how infrared detectors are made. The device that we sent to Mars was one such minidetector, the only such device in the world that met the requirements of the National Aeronautics and Space Administration (NASA).


The Curiosity rover

The purpose of the mission was to detect radiation with the highest possible degree of sensitivity and use it to obtain information about the chemical composition of the samples collected on Mars. Researchers at NASA were particularly interested in the methane content in those samples.

How does this work in practice?

The rover that landed on Mars collects a rock or gas sample and then puts it into a chamber that contains a laser and our detector. The focus of the research is on methane, which allows us to look very far back into the history of Mars. Most of the Earth's methane comes from living organisms, from various decomposition processes. The laser light reflects off the sample and reaches the detector. If the sample contains methane, the detector will transmit a modified signal. We can then say that the sample contains traces of methane and determine its amount; its presence is a sign that life is highly likely to have once existed on Mars. Such traces of methane were indeed first discovered on Mars during Curiosity's mission in 2014. Moreover, they were identified by detectors we had designed.

In the next stage, the European Space Agency (ESA) sent our sensors to Mars as part of the ExoMars mission. The requirements were somewhat less stringent than in the case of NASA. The search for methane continues, and we are working on creating even more advanced systems. Today, we focus not only on conductive components but also on more complex sensors with electronics. We hope that in the next mission to Mars we will send a system that will, for example, be able to observe the surroundings from a position on the robot's arm, instead of being installed inside the probe. We have just returned from a major conference in San Francisco, where we talked to our clients in the United States about advancements in efforts to fine-tune existing ideas.

Could the sensitivity of detectors be even greater? Is it worth working on such projects?

Sensitivity, or responsivity, are basic parameters that describes these detectors. Precisely speaking, they describes how a detector reacts to signals coming from the outside. When we talk about voltage responsivity, for instance, we measure the voltage on the detector after it is hit by a quantum of light. Detectors essentially operate based on the principle that sensitivity must be adequately high and noise adequately low. I work with a team of technologists who started their careers back in the 1960s, and everyone has always prioritized the highest possible sensitivity. But in addition, it is important for a detector to use as little energy as possible and to be easy to operate.

What can be done to improve the sensitivity of detectors? You have pioneered a method that allows detectors to operate without cooling. Why is this important?

A fundamental way to further boost the sensitivity of sensors involves lowering their temperature by cooling them with liquid nitrogen. In the past, this was done with the help of dewars (a special type of vacuum flask). However, my father and his doctoral students, who together founded this company, concluded that the existing system of cooling limited the industrial use of infrared detectors. Every gas, and every chemical compound in general, has its own characteristic signal in infrared, something like a fingerprint, which can be detected by an appropriate detector. But if such a device must be cooled manually with liquid nitrogen every hour, there's no longer any point using it. However, detectors may be cooled with the help of miniature semiconductor-based heat pumps or may require no cooling thanks to refined semiconductor technologies. Our method of producing detectors is based on a complex process developed by specialists in many disciplines, with each specialization playing a role at one of the stages of productions. First, physicists design the structure of a crystal, a model that will allow us to obtain the best possible functioning of the detector. Then, technologists grow such a crystal and arrange its atoms according to the model. After that, measurement specialists check how far the model is from a conductive layer. Finally, this process must be repeated many times to make sure that it is replicable, reliable, and cost-effective. In effect, we get a highly sensitive detector that requires minimum or no cooling, without costly cooling systems or maintenance.

Infrared photon detectors

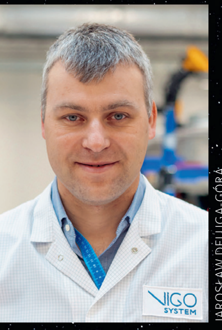
Apart from the search for life beyond the Earth, what else could this technology be used for?
Two major areas in which our detectors can be used are measuring the temperature and measuring the chemical composition of gases, liquids, and solids. An example of the former use involves monitoring the operation of high-speed trains. In Europe, such trains must be inspected after every few tens of kilometers to make sure that, for example, a brake is not blocked or a wheel is not deformed. Here, temperature serves as an indicator – when anything goes wrong, we can detect the resulting overheating. Detecting objects and threats as well as smart ammunition are other areas in which sensors may be used to reduce damage during war. All Polish-made tanks have our detectors, which can detect if someone is out there aiming at them.

The biggest area in which detectors may be used is environmental protection. This applies in particular to measurements of emissions from power plants, combined heat and power plants, and factories. Our detectors are installed on the chimneys of these facilities to monitor emissions, so as to help keep emissions of nitrogen and sulfur dioxide and other greenhouse gases under control. Such emissions are monitored by environmental protection agencies, which may impose fines if limits are exceed. In such situations, detectors serve as certified devices that measure and regulate emissions. In China, a pilot project is ongoing in which detectors are installed on street lamps to monitor a specific area, checking if nearby factories may have started to pollute the air, and if so, then which factories these are. This is an example of preventive ways to verify emissions of pollutants.

Does this mean that detectors can help make sure that the air we breathe is clean?
Yes. A breakthrough in this field came with the Summer Olympics in 2008 in Beijing. Many athletes pledged to boycott the games unless the air in China's capital was clean enough. Back then, our detectors were used. With the help of scientists from Princeton University, they were included in an air quality monitoring system. They helped reduce pollution by indicating when the air reached a desired level of quality. This prompted athletes to come to China, and the games could be held. Back then, the Chinese ordered many detectors from us, so we could launch production on a large scale while keeping the costs down. Now, we have many industrial clients of this type, and the market is growing at a rate of over 20% a year. Our clients often started as start-ups, implementing new and unique solutions that over time became used on a mass scale and now represent a major area of growth for us.

In the 1990s and 2000s, we chiefly had clients from the scientific sector. In recent years, in turn, we have observed growing interest on the part of factories, which rely on automated processes. Quality control of pharmaceuticals is a completely new field. Here, detectors are used for example to check if the white powder being tested is definitely paracetamol. Such tests are quite difficult, but they are nonetheless possible thanks to the use of infrared detectors. Our company's growth and the new opportunities that are opening up for us have prompted us to search for fields of collaboration with research centers and employ significantly more specialists. We work to educate our staff, we are involved in educational programs at universities, and host research done for the purpose of doctorates. We also coordinate the training of specialists together with other employers in the sector of photonics and high technology.

Interview by Dr. Justyna Orłowska



JAROSŁAW DELUGA-GÓRA

Adam Piotrowski, PhD
A graduate of the Warsaw University of Technology and the Military University of Technology (WAT) in Warsaw. He earned his PhD in engineering at the Military University of Technology. In 2008–2014, he headed the Department of Detectors at Vigo System S.A. Since 2014, he has served as the company's CEO.
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