SPECTROSCOPY

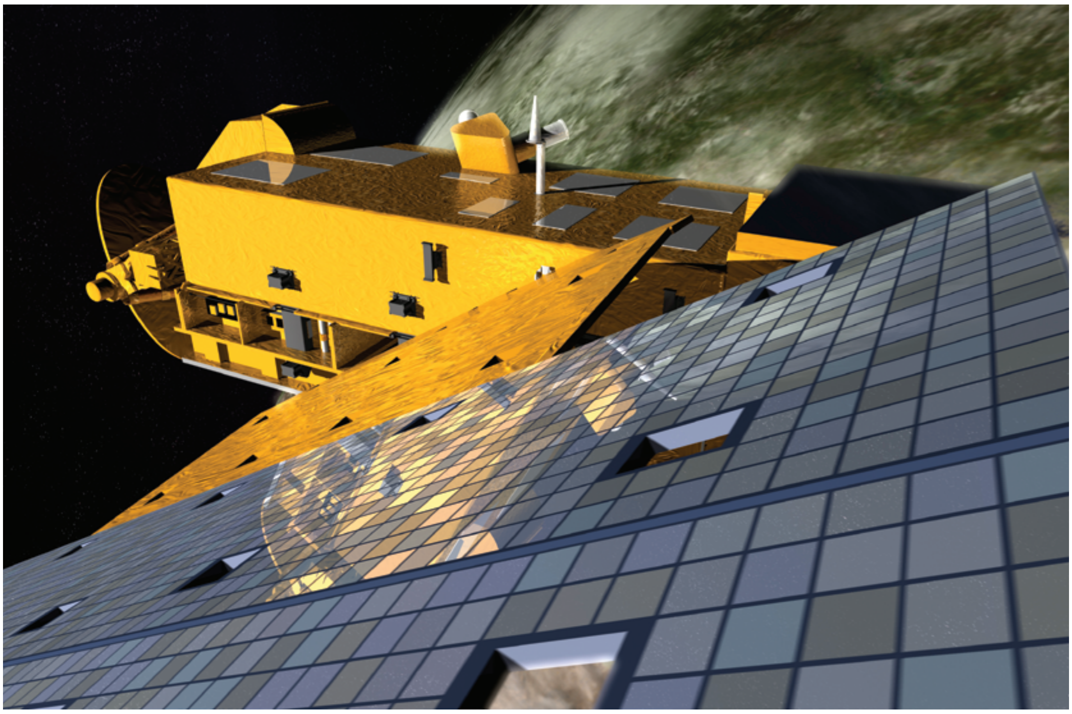

Figure 1. The OMI satellite, launched in 2004 and containing a spectrometer which opto-mechanics are designed and built by TNO, shows that spectroscopy enables measurements kilometres away from the sample. Image courtesy NASA.

TNO innovation for life

Spectroscopy is the study of the interaction between light and matter. For TNO this means: chemical identification and characterisation with light. Determining the composition of a sample is necessary in a lot of situations, for example determining the composition of the atmosphere, rocks or your blood. Using light has many advantages, such as the possibility to cover large distances and work contactless.

TNO designs and develops prototypes of measurement probes and telescopes, as well as the spectrometer itself. TNO has expert knowledge on optical design, ray-tracing, stray-light analysis, tolerancing, mechanical design, optical manufacturing (including freeform optics), mechanical manufacturing, alignment and calibration. We closely collaborate with partners that are specialised in the development of light sources and cameras. Therefore, we offer a one-stop shop in the production of customised instruments. TNO also works closely with companies that specialise in volume production of all required components.

ADVANTAGES OF SPECTROSCOPY

There are a number of advantages of using light to identify and characterise matter:

- Light requires no physical contact between samples and the instrument.
- One has the freedom to position the instrument either directly on the sample (for instance on skin), but also kilometres away (for instance on a satellite, see Figure 1).
- No sample preparation is needed.
- The results can be quantitative.

WHY TNO?

TNO spectroscopic instruments are used by world-leading international institutes including ESA, NASA and ITER. When exposed to incredibly harsh environments such as the plasma in a nuclear fusion or on satellites in space, performance matters like nowhere else. The instruments developed by TNO are able to perform in these extreme environments and are reliable over years of operation.
TNO is now drawing on this unmatched expertise and brings space equipment to applications in daily life.

TYPES OF SPECTROSCOPY

TNO focuses on three types of spectroscopy: 1) absorption spectroscopy; 2) Raman spectroscopy; and 3) Laser Induced Breakdown Spectroscopy (LIBS).

ABSORPTION SPECTROSCOPY

Absorption spectroscopy is a technique that can determine chemical composition, e.g. atmospheric (trace) gas concentrations such as ozone, CO_2, methane and NO_x.
TNO has an excellent track record in

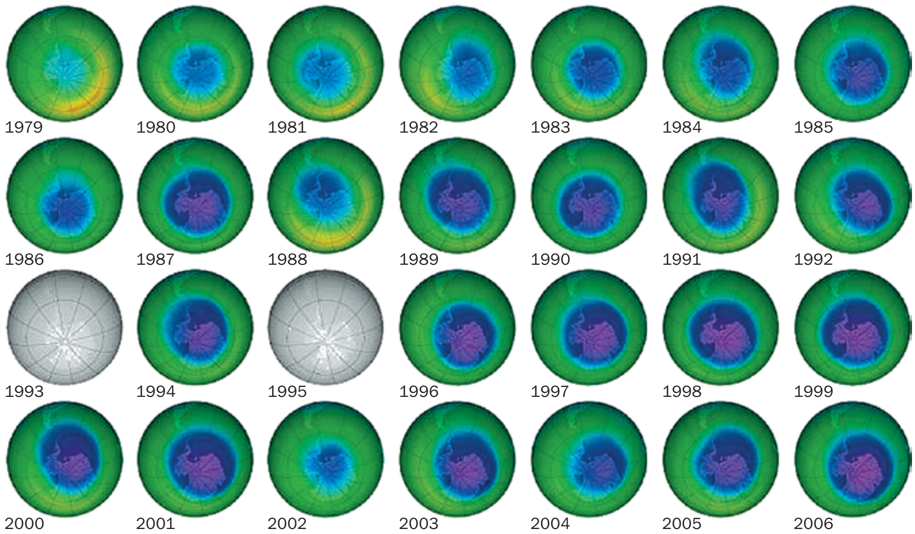

Figure 2. Spectroscopic measurements showing the hole in the ozone layer. Image courtesy NASA.

space-based imaging absorption spectroscopy: three instruments have been successfully launched as satellite payloads since 1995 and all are still in orbit and operation today. With one of these instruments, the hole in the ozone layer was measured (see Figure 2). In addition to atmospheric applications, absorption spectroscopy can be applied on liquids and even solids for ground-based applications.

RAMAN SPECTROSCOPY

Raman spectroscopy is a non-destructive technique for quantifying the chemical composition of a sample and identifying the phase of materials. It is based on the observation of molecular and phonon vibrations and provides a molecular fingerprint of the sample. TNO realised Raman systems that are able to discriminate between cancerous tissue and healthy tissue, or systems that are able to determine the glucose content in blood in a non-invasive manner. Figure 3 shows the first generation of such a miniature Raman spectrometer designed and prototyped by TNO. It is suitable for low cost, high volume applications such as medical diagnostics and potential mobile phone integration.

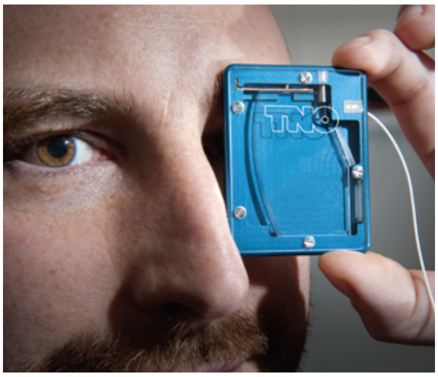

Figure 3. The first generation of a miniature Raman spectrometer designed and prototyped by TNO.

LASER INDUCED BREAKDOWN SPECTROSCOPY

LIBS is an ultrasensitive approach to determine and quantify the elemental composition of a sample, without the expense and complexity of mass spectrometry. In combination with Raman, TNO can deliver both elemental and molecular characterisation of a sample. With LIBS instrumentation, TNO enables real-time monitoring within the industry, e.g. product and material streams on conveyer belts. For example, TNO developed a LIBS instrument that is able to discriminate valuable ore from useless ore coming from a mine.

Table 1. TNO offers high end spectroscopy in a very small volume in three different scenarios.

	Broadband version	**Raman version**	**Absorption version**
Bandwidth	400-800 nm	830-930 nm	2000 - 4000 nm
Resolution	2.5 nm	3.4 cm^{-1}	4 nm
Slit size	50 µm	50 µm	50 µm
F-number	f/2	f/2	f/2
Dimensions	65×43×8 mm incl. housing	70×66×6 mm excl. housing	TBD
Status	Hardware available	Hardware available	Conceptual design stage

Table 1 shows an example of an innovative spectrometer approach developed by TNO. By choosing for a monolithic approach of the complete spectrometer, its size can be reduced, while its performance is kept comparable to large laboratory equipment. The basic compact design can be altered for specific applications. Dedicated customer specifications are also possible.

TNO

TNO is an independent innovation organisation that connects people and knowledge in order to create the innovations that sustainably boost the competiveness of industry and wellbeing of society.

TNO works for a variety of customers: governments, the SME sector, large companies, service providers and non-governmental organisations. Working together on new knowledge, better products and clear recommendations for policy and processes. As a ‘knowledge broker’, TNO advises their customers on finding the optimum solutions that are geared precisely to the questions they have.

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