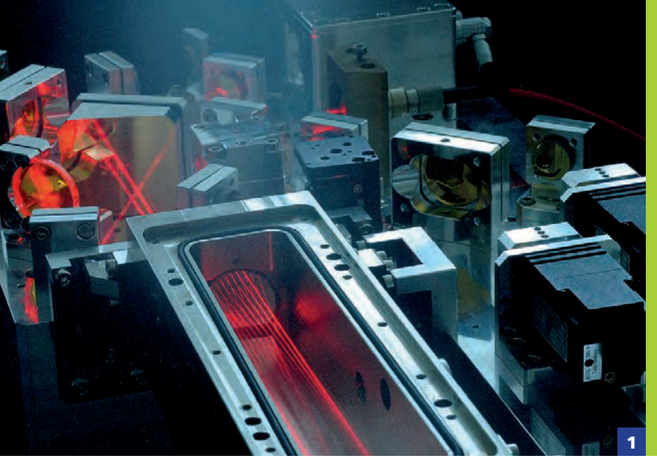

1 *Fraunhofer IPM's QCL analyzer detects laughing gas with a very high degree of sensitivity.*

SPECTROSCOPY AND PROCESS ANALYTICS

Quantum cascade lasers for rapid exhaust gas analytics

European emission legislation is becoming more and more stringent both for industry and for the automotive sector. Climate protection can work only if air pollution by vehicle exhaust gases is reduced constantly. Fraunhofer IPM has developed a reliable exhaust gas measurement system for development of reduced-emission engines. In particular, it can also be used to detect laughing gas, a gas which has a particularly negative impact on the environment. The system is based on infrared absorption spectroscopy using quantum cascade lasers as the light source in conjunction with a specially designed sampling system.

As early as in past decades, more stringent exhaust gas legislation led to the introduction of a whole number of new technologies for reducing emissions. Exhaust gas treatment has also become increasingly more complex. Admittedly, it was possible to achieve major success with the first three-way catalytic converters, but the emission of undesirable gases still continues to preoccupy both scientists and automobile manufacturers alike – in particular in the field of engine development. During the course of this development process, demands on measuring accuracy are becoming ever-more stringent: the call for detection limits in the region of 10 ppb are no longer a rarity (ppb = 1 part per billion).

New technology for extreme measuring requirements

Current legislation relating to greenhouse gases for example already requires measurements of laughing gas (N_2O) in very low concentrations of below 1 ppm (ppm = 1 part per million). The gas, also referred to as nitrogen monoxide, is mainly produced during decomposition of mineral nitrogen fertilizer in the soil, but is also generated when combusting fuel in internal-combustion engines. Conventional technologies which have been used to date for measurements of N_2O – such as non-dispersive infrared technology (NDIR) or electrochemical gas sensors – are either too insensitive for today's measuring requirements or they demonstrate excessive cross-sensitivities.

An optical spectrometer based on quantum cascade lasers (QCL), developed by Fraunhofer IPM jointly with an industrial partner, now, for the first time, permits exhaust gas measurement which meets the more stringent requirements. The gas analyzer is capable of reliably detecting laughing gas in very low concentrations, in the range of 10 ppb to 100 ppm (4 decades). The QCL analyzer applied is highly selective in relation to the other components in the particular gas matrix such as that typical of the exhaust gas from internal-combustion engines.

Quantum cascade lasers are semi-conductor lasers for wavelengths in the medium infrared range (MIR). Unlike other lasers which emit in the MIR range, the QCL has a comparatively high output power and also operates at room temperature – a complex and expensive cooling system is no longer required. The laser temperature is stabilized and consequently the emission wavelength is also stabilized using a conventional Peltier element with a corresponding ventilation system. The control system is designed for laser operating points between –30 °C and +30 °C.

Industrial systems for automobile manufacturers

Fraunhofer IPM was able to take recourse to its many years of experience in the field of exhaust gas measurement systems when developing the N_2O exhaust gas measurement system: as early as 2002, Fraunhofer IPM developed an industrial measurement system for high-speed, high-sensitive and selective detection of carbon monoxide, nitrogen monoxide and nitrogen dioxide with the QCL-based exhaust gas analyzer DEGAS (Dynamic Exhaust Gas Analyzer System) for a major automobile manufacturer. DEGAS permits simultaneous measurement of the concentration of various exhaust-gas components with a time resolution of five milliseconds at up to four measuring points on the exhaust gas system.
The new QCL analyzer which has now been developed is intended for instrument cabinet applications and is thus designed as a substantially more compact unit; in addition, the next expansion stage is to be able to detect two gas components simultaneously. The QCL analyzer is not only already being used successfully in research and development but also to an increasing extent for certification measurements on reduced-emission engines.

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FRAUNHOFER IPM primarily conducts research in the field of gas and process technology and uses a wide range of spectroscopic methods for this purpose. In addition to laser spectroscopy, the expertise of the institute also extends to many classic methods such as Fourier transform IR spectroscopy (FTIR), photometry, filter, UV and Raman spectroscopy and photoacoustics.

2 *Developing engines producing less emissions is a major challenge for today's scientists and for the industry.*