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GROUP **INTEGRATED SENSOR SYSTEMS**

Sulfur sensor for use on the high seas

Ship emissions heavily pollute marine ecosystems and are extremely detrimental to the health of humans in harbor areas. Alongside carbon dioxide and nitrogen oxides, seagoing vessels primarily emit large quantities of sulfur oxides. A new photoacoustic sensor system has now been developed that is intended to enable continuous monitoring of maritime SO_x emissions in future. This will be many times cheaper than the SO_x measurement systems currently available, yet will deliver comparable performance.

Sulfur oxides can trigger lung and cardiovascular diseases, and as water-soluble gases they contribute to the acidification of bodies of water and soil. However, low-sulfur marine fuels are far more expensive than heavy fuel oil. For this reason, shipping companies will continue to use heavy fuel oil in future, regardless of the stricter limits. Gas scrubbers installed on board ships will therefore be used to purify exhaust gas, removing harmful sulfur oxides to bring emissions into line with those of low-sulfur fuels.

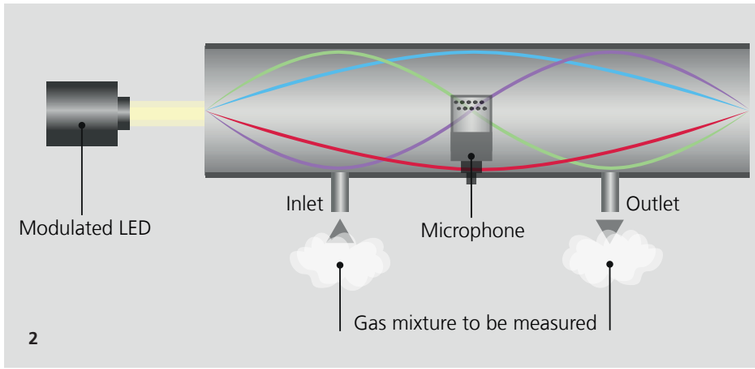
Measuring actual emissions

The International Maritime Organization's gauge for judging emission control is the actual output of SO_x, irrespective of the fuel used. Special exhaust gas measuring technology, which determines emission values every four minutes, will therefore be mandatory from 2020 on. Fraunhofer IPM is working together with industrial partners to develop a low-cost, photoacoustic sulfur oxide sensor system for marine use. The sulfur oxide measurement systems currently available on the market cost between 50 and 150 thousand euros – meaning that retrofitting an entire fleet will be a sizeable investment for ship-owners.

Photoacoustics: high measurement accuracy with inexpensive components

Photoacoustic sensors operate by converting light energy into sound. Here, the absorption of electromagnetic radiation by gas molecules is detected directly using a pressure transducer, which identifies the increase in pressure resulting from this absorption. Today's photoacoustic SO_2 measurement systems operate with relatively expensive lasers. The new sensor system, however, aims to employ low-cost, commercially available UV LEDs as light sources and microphones as detectors. As a result, the anticipated cost of such sensors is in the region of 5000 euros, in other words more than ten times cheaper than the current technology. The relative ease of handling provides a further advantage. Laser-based photoacoustic sensors are costly and difficult to stabilize, particularly under harsh measurement conditions. In the new sensor system, scientists use high power UV LEDs in a wavelength range of 270 to 310 nm, which corresponds precisely to an SO_2 absorption peak in the UV range. This prevents cross sensitivity to other gases. The aim is to achieve measurement accuracy in the region of 0.1 ppm. Depending on the exact process, photoacoustic systems employ virtually no mechanical parts, allowing them to operate maintenance free for a period of at least 12 months.

STRICTER EXHAUST GAS LIMITS FOR INTERNATIONAL SHIPPING From 2020 on, the International Maritime Organization (IMO) is imposing tighter limits on global sulfur emissions. The current limit on sulfur content in heavy fuel oil is set at 3.5 percent – and is thus up to 3500 times higher than the value permitted for motor fuel. In future, the SO_x emissions from seagoing vessels will be required to have a fuel sulfur content of just 0.5 percent. The so-called »Emission Control Areas« in the EU and the US already impose limits of 0.1 percent.



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1 In future, on board measurement technology will ensure that stricter limits on air pollutants are met.

2 The light is guided into the measurement cell through a window. A microphone records a photoacoustic signal in the gas flow which provides information on the concentration of different gases.

The key component in a resonant photoacoustic sensor system is the measurement cell. Light from the UV LED is guided into the cell through a window incorporated into its side. Gas exchange occurs through an inlet and outlet aperture. A commercial microphone measures the photoacoustic signal. Initial tests with CO_2 show that measurements can be performed under gas flow, removing the need for additional valves and pumps to extract the gas samples. Work within the »E-MASUM: Marine Sulfur Monitor« project, funded as part of the Eurostars program, focuses on measuring SO_2, which constitutes 95 percent of sulfur oxide emissions. A later sulfur monitor will be equipped with an additional CO_2 sensor, allowing sulfur concentrations to be analyzed in relation to fuel consumption. To ensure that the sensors are suited to use in a marine environment from the very outset, the project partners are working closely with manufacturers of marine gas scrubbers and sensor systems. A field test demonstrator is being operated until the project concludes in 2018, and is intended to show that photoacoustic measurement systems can work reliably on board seagoing vessels. The majority of the 90,000 ships that cross the world oceans will need to install gas scrubbers and corresponding measurement technology in the near future — the market potential is therefore immense.

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