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FRAUNHOFER INSTITUTE FOR PHYSICAL MEASUREMENT TECHNIQUES IPM

1 *Monitoring the proliferation of fire extinguishing gas in time and space is crucial in the development of compact fire extinguishing units.*
2 *Measurement chamber of a Fraunhofer IPM satellite spectrometer for measuring the proliferation of extinguishing gas.*

RAPID GAS MEASUREMENT
WITH COST-EFFECTIVE NIR SPECTROSCOPY

Infrared Spectroscopy with Filter-Based Spectrometers

Gases typically exhibit a highly characteristic absorption in the infrared spectrum of light, which can be used to monitor gas concentrations and their changes in complex mixtures. Unfortunately, in order to record a complete spectrum in the infrared the hardware investment is quite high, e.g. when using FTIR (Fourier-Transform-Infrared) spectrometers or grating spectrometers with moving mechanical parts. However, in many cases the gas variety to be detected is known and does not consist of more than a few gases. In order to distinguish these few components, a complete spectrum with high spectral resolution is unnecessary, which provides the opportunity of a much simpler, significantly less complex approach. Fraunhofer IPM develops custom filter-based infrared spectrometers consisting of simple source-sample-detector setups adapted to customer needs for process technology, safety, security, or automotive applications. By limiting the spectral resolution to a few filter regions in the infrared, we are able to speed up the acquisition time into the millisecond range and provide a cost-effective and fast solution for gas monitoring with the following main advantages:

- Fast temporal resolution down to milliseconds
- Small form factor
- Robust and long-life mechanics
- Competitive price
- Possibility to multiplex
- Flexibility by changeable filters

Fraunhofer IPM offers complete solutions to gas monitoring needs including:

- Evaluation of the measurement challenge and the applicability of filter-based spectrometers
- Filter selection based on conventional high-resolution FTIR spectra of the involved gases

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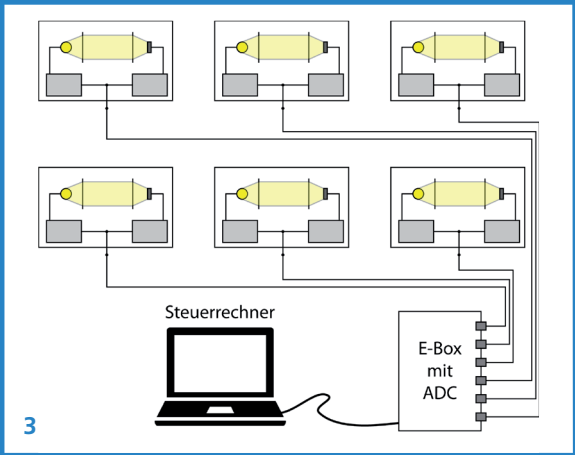

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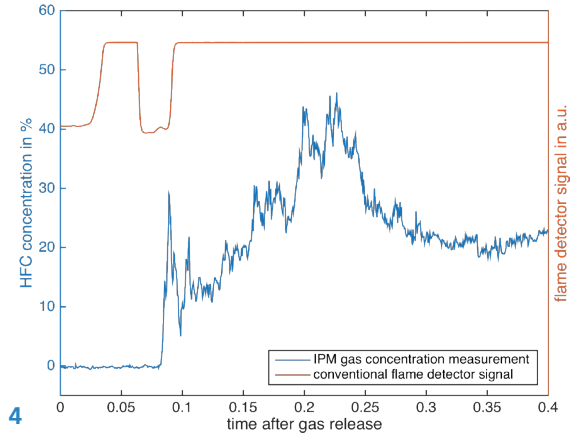

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- Optical design and simulation
- Design and manufacturing of mechanics and electronics
- Chemometric data analysis
- Software development
- Calibration and testing

Example: Monitoring of Fire Extinguishing Gas in Space and Time

Monitoring the proliferation of fire extinguishing gas in time and space is a key factor in the development of compact and effective fire extinguishing units. In a joint project with Federal Armed Forces Scientific Institute for Protection Technologies – NBC Protection (WIS = Wehrwissenschaftliches Institut für Schutztechnologien – ABC-Schutz) Fraunhofer IPM developed a system to monitor fire extinguishing gas proliferated in land vehicles, ships or aircrafts operated by the German armed forces. To guarantee a proper gas concentration bandwidth (enough to extinguish the fire, not too high to harm personnel) in all parts of the interior within a few hundred milliseconds after proliferation, the concentration of the extinguishing gas is monitored at six positions and with a time resolution of less than a millisecond.

Fraunhofer IPM developed a small-footprint LED-based filter spectrometer which is used in six identical copies to work as acquisition satellites. A central digital-to-analog converter-box digitizes all signals from the spectrometers. Each spectrometer is equipped with two near-infrared LEDs. Their emitted light is guided and spectrally cleaned by a dichroic beamsplitter and sent through a 50-cm-long light path through the ambient air and focused on a single detector. The LEDs are pulsed alternately, one LED monitors the extinguishing gas absorption, the other one is sensitive to light extinction due to fogging which is a typical side effect of a massive gas proliferation. Thus, the extinguishing gas absorption signal is corrected for the fogging effect and correlates with the gas concentration. In summary, the measurement system provides synchronized, time-resolved gas concentrations from six probes placed inside the vehicle interior.

Technical Specifications	
Time Resolution	*0.5 ms*
LED wavelengths	*2.1 µm and 2.3 µm*
Optical path	*50 cm*
Measuring range	*gas concentrations between 0 % and 100 %*

Currently 6 spectrometers in one system, easily adaptable

Custom System Development

The spectroscopic system outlined above may easily be adapted to customer needs. Different geometric platforms and alternative LED and filter wavelengths may straightforwardly be implemented.

Additionally, Fraunhofer IPM is your competent partner for diverse spectroscopic applications. We offer an extended adaptation to your measuring needs including solutions for sample preparation, data analysis (image processing, chemometrics) and technical evaluation.

3 *Schematic overview of a spectrometer setup to monitor gas concentrations in space and time with six spectrometer satellites and central data acquisition.*

4 *Comparing the Fraunhofer spectrometer to a conventional flame detector: The measured gas concentration (blue curve) rises at 80 ms after gas release, which is in agreement with the final off-signal of the flame detector (red curve). Additionally, the concentration signal is not influenced at all by the blast wave causing the flame signal perturbation at around 25 ms.*