

- 1 Compact White cell.
- 2 Field mirror of a White cell optimized for quantum cascade lasers.

MULTI REFLECTION GAS MEASUREMENT CELLS FOR ABSORPTION SPECTROSCOPY WHITE AND HERRIOTT CELLS

High sensitivity by long optical paths

Measuring low gas concentrations requires long optical paths in order to obtain satisfactory detection limits. For low quantities of gas or a high temporal resolution the volume of the measurement cell should be as small as possible. This is the only way to guarantee an efficient, rapid gas exchange. Multiply reflecting the measurement beam between mirrors allows keeping the dimensions of the cell low and, at the same time, ensures a sufficient optical path. Fraunhofer IPM develops compact and robust multi reflection gas measurement cells with long optical path lengths for scientific and industrial applications. Next to standard White or Herriott measurement cells Fraunhofer IPM also realizes special designs according to customers' requirements. The cells are adjustment-free and can be operated with

different light sources. They are fit for use in a broad spectral range, from UV to far infrared.

White Cells

White cells – named after J. U. White [1] – are used for different spectroscopic measurement scenarios. They are suitable for collimated (e.g. lasers) as well as for divergent emitters (e.g. thermal sources). Fraunhofer IPM uses White cells for laser spectroscopy in the near infrared (NIR) and mid infrared (MIR) spectral range. In addition, White cells are employed in filter spectrometers in combination with thermal emitters. White cells are characterized by their extremely compact design, featuring a small internal gas volume and an optical path length of several meters. The light is guided by three optical mirrors.

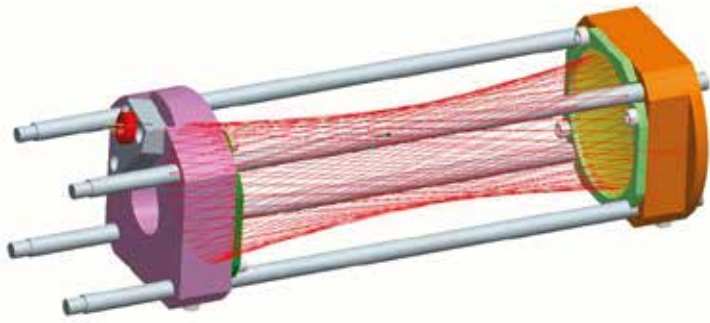
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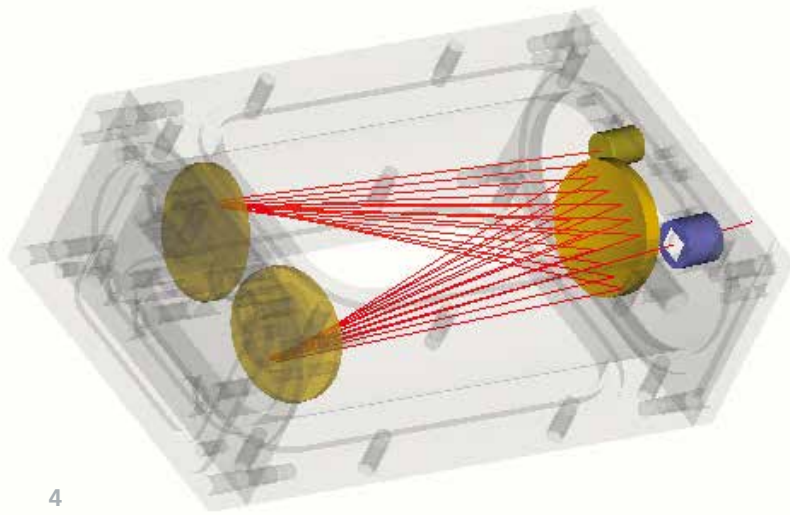
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Measurement setups combining White cells and Vertical Cavity Surface Emitting Lasers (VCSEL) are, for instance, applied for determining O_2 concentrations in natural gas. Used with quantum cascade lasers White cells enable the selective determination of ppb level impurities in hydrocarbon gas mixtures. In combination with thermal emitters, White cells are used for measuring ethylene concentrations in fruit ripening processes or monitor CO concentrations in fuel cells.

Herriott Cells

A Herriott cell – named after its inventor D. R. Herriott [2] – consists of two opposed spherical mirrors. The optical path length is primarily determined by the distance between the mirrors and the number of reflections. The off-axis coupling of the measurement beam generates a concentric spot pattern at the mirror edges. This effect allows a significant reduction of the gas volume by using a centric inner

pipe. In contrast to White cells, Herriott cells are operated with collimated lasers only. The laser can either be directly integrated into the cell or fiber-coupled into the measurement setup. Herriott cells in combination with VCSEL – featuring emission wavelengths which correspond to the absorption patterns of the analyte – are suitable for measuring O_2 or CO exhaust gas concentrations in combustion plants or detecting accidental oxidation in reaction chambers.

Specifications of typical White and Herriott cells

cell type	pathlength m	gas volume ml	coupling aperture $F\#_c$	transmission %
White »compact«	1.6–3.2	150	3.5	50
White »reference«	1.44–8.7	230	7.2	81–23
White »Stromboli«	2.8–11.0	48	58	92–63
Herriott »compact«*	5	40	25	20
Herriott »vacuum«	15	770	30	75

* specially developed for Siemens AG

[1] J. U. White, Long paths of large aperture, *J. Opt. Soc. Am.* 32, 285 (1942)

[2] D. R. Herriott and J. H. Schulte, Folded optical delay lines, *Appl. Opt.* 4, 883, (1965)

3 Design of a Herriott cell.

4 Design of a White cell.