Towards a sensor-based methodology to determine online calorific values of H_2-enriched natural gases in the grid

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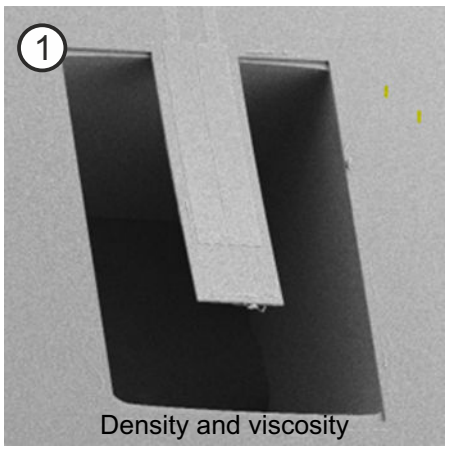
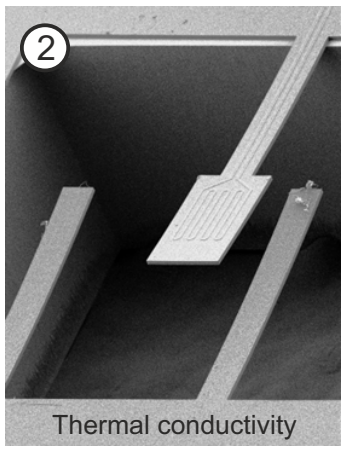
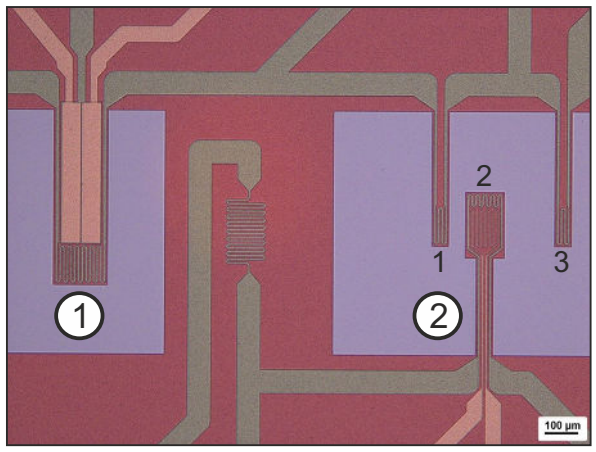
Cantilever-enhanced sensing

MEMS sensor for measuring gas density, viscosity, and thermal conductivity

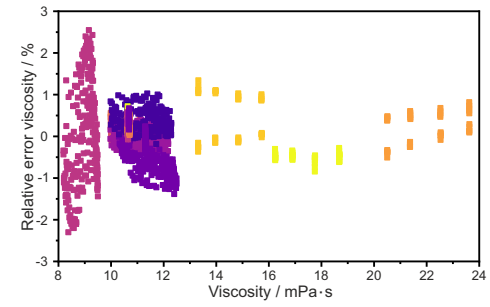


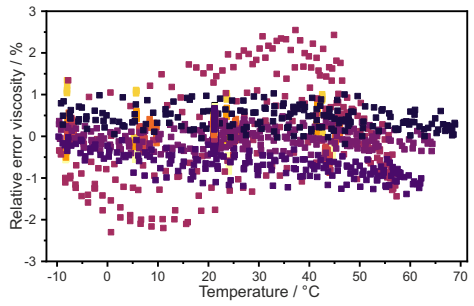


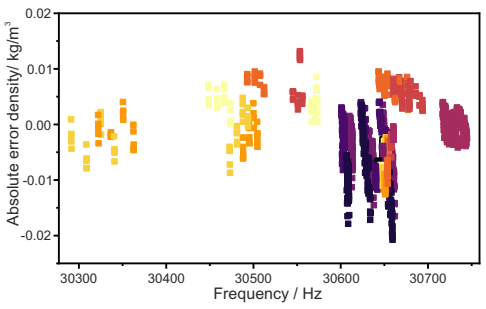


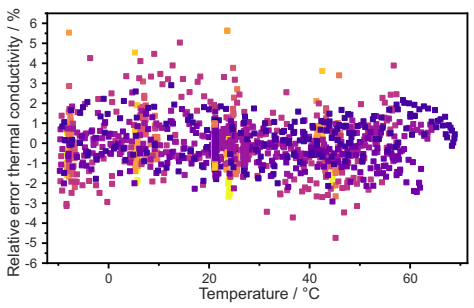
1. Density and viscosity:
In the first measuring cavity is a micro-mechanical cantilever made of polysilicon, which is piezoelectrically excited. The resonance frequency and the quality factor of the oscillator are measured. These parameters are highly sensitive to the density and viscosity of the surrounding medium.

2. Thermal conductivity:
The second measuring cavity contains three additional cantilevers. The central cantilever operates with a constant heating power while its temperature is continuously monitored. A proximate cantilever acts as a gas temperature sensor. The thermal conductivity of the gas is determined from the temperature difference between the heater and the sensor.









Third-party comparison sensors

1. H2scan HY-OPTIMA 5034:
The HY-OPTIMA 5034 uses a hydrogen-specific, resistive sensing element. Hydrogen diffuses through a selective barrier to the sensing element, where it causes a reversible change in the sensors electrical-resistance. According to the manufacturer, this barrier is resistant to up to 20 Vol-% CO and 3 Vol-% H_2S, which reduces potential interference from these compounds and supports a more selective response to hydrogen

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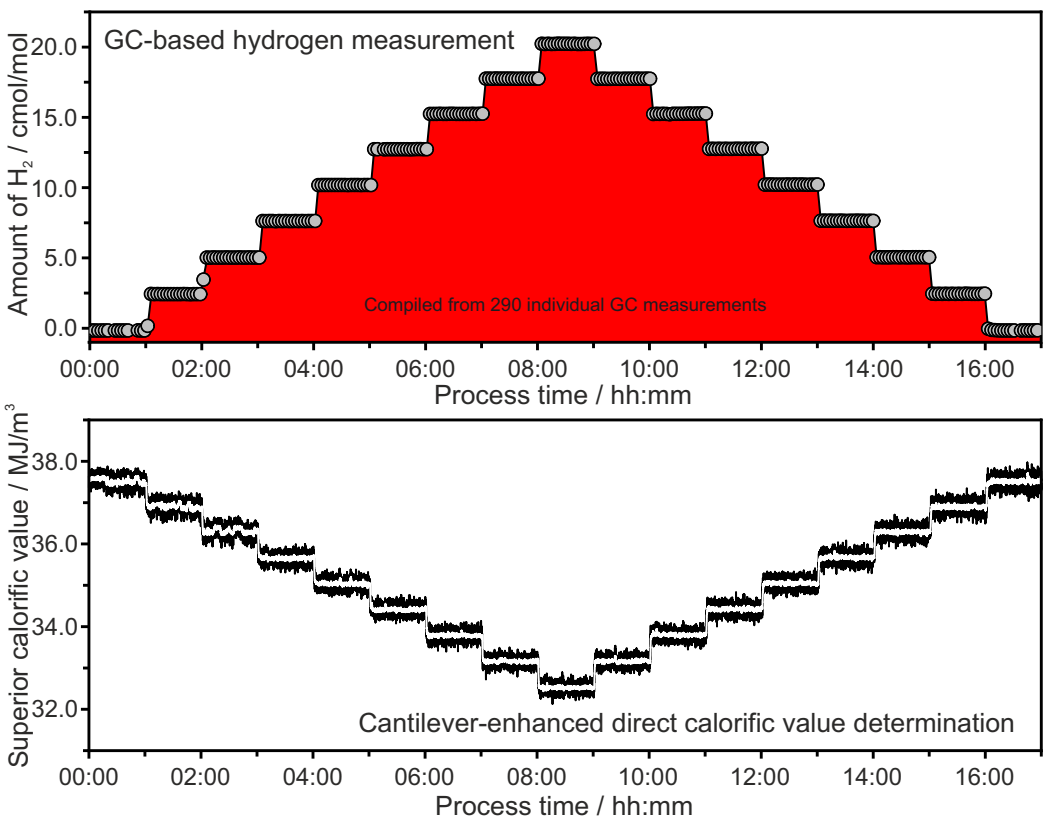
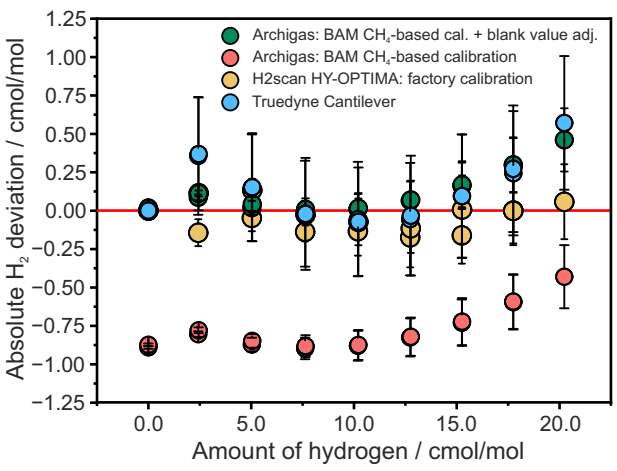
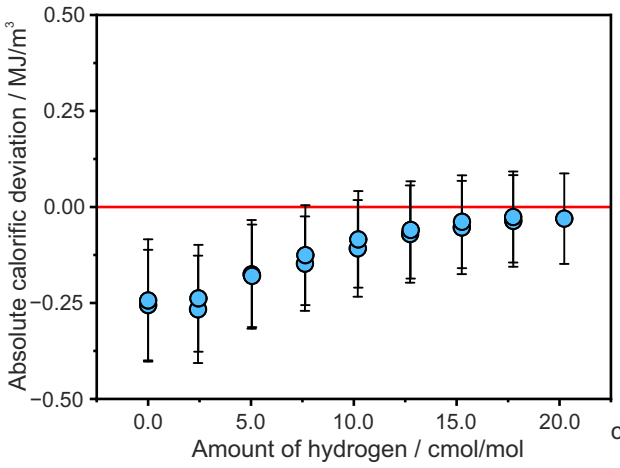
2. Archigas TCD3000:
The Archigas TCD3000 Transmitter operates on the thermal-conductivity measurement principle. The method is particularly suited to (quasi-)binary gas mixtures with strongly different thermal conductivities (e.g., H_2 vs. O_2, CH_4 or Ar)

Calorific- & hydrogen sensing in an 11-component high-calorific natural gas mixture







Hydrogen was added to a synthetic high-calorific natural gas blend (CH_4: 97.3 %, N_2: 1.35 %, CO_2: 0.35 %, C_2H_6: 0.40 %, C_3H_8: 0.20 %, *n*-butane: 0.10 %, *i*-butane: 0.10 %, *n*-pentane: 0.05 %, *i*-pentane: 0.05 %, neopentane: 0.05 %, *n*-hexane: 0.05 %) by dynamic dilution. This process generated hydrogen-enriched natural gas blends, which were investigated using GC-TCD for H_2 reference value determination, as well as for chemical and physical sensing.

Cantilever-based H_2 quantification in natural gas shows good to excellent agreement from 5 to 15 cmol/mol and adequate performance outside this range. Its direct calorific value determination also shows that the quantification error did not exceed 0.8 %. The HY-OPTIMA demonstrates an excellent level of H_2 measurement performance throughout. On a CH_4-based H_2 calibration, the Archigas H_2 quantification shows a negative bias.Through blank value compensation of the readings, the measurement performance is similar to that of the Cantilever, but with less noise.The similar H_2 deviations measured by the cantilever and compensated Archigas readings suggest method-specific effects, as both rely on thermal conductivity measurements.

Sicherheit in Technik und Chemie