GAS
SECURE
A Dräger Company

MEMS technology for safe, wireless infrared gas detection

Location: Rotterdam, The Netherlands
Presenter: Dr Christian Heinlein, GasSecure
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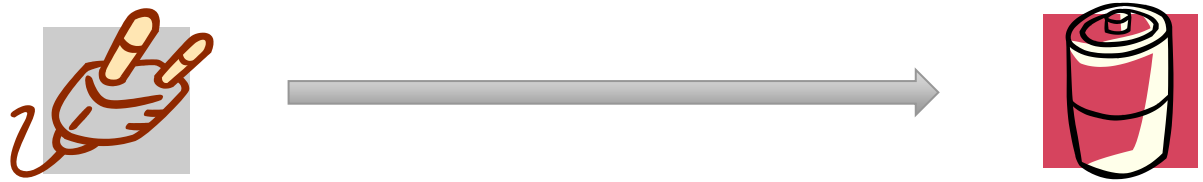
Outline

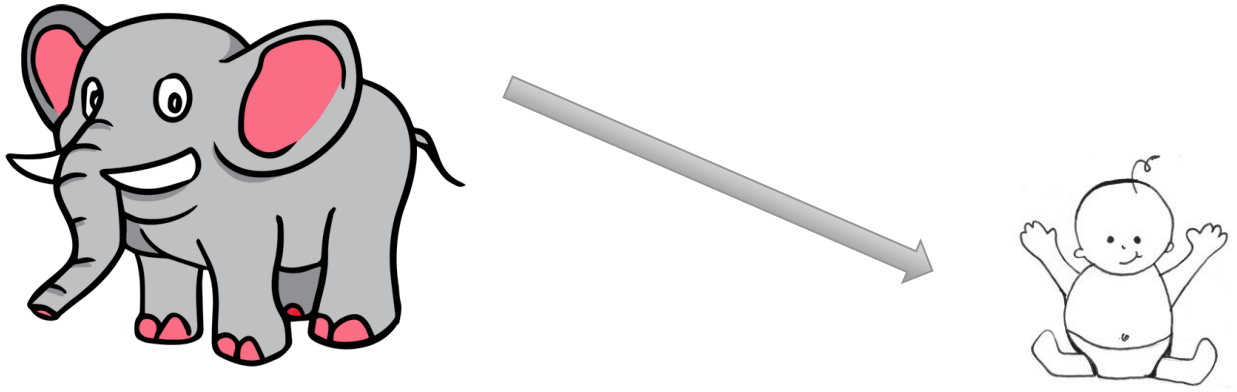
- From traditional infrared to wireless gas detection
- MEMS technology
- Proprietary MEMS filter for hydrocarbon gas detection
- Low power MEMS source

The Technological Challenge for Wireless Gas Detection

Reducing energy consumption by **three** orders of magnitude

5 W 500 mW 50 mW 5 mW



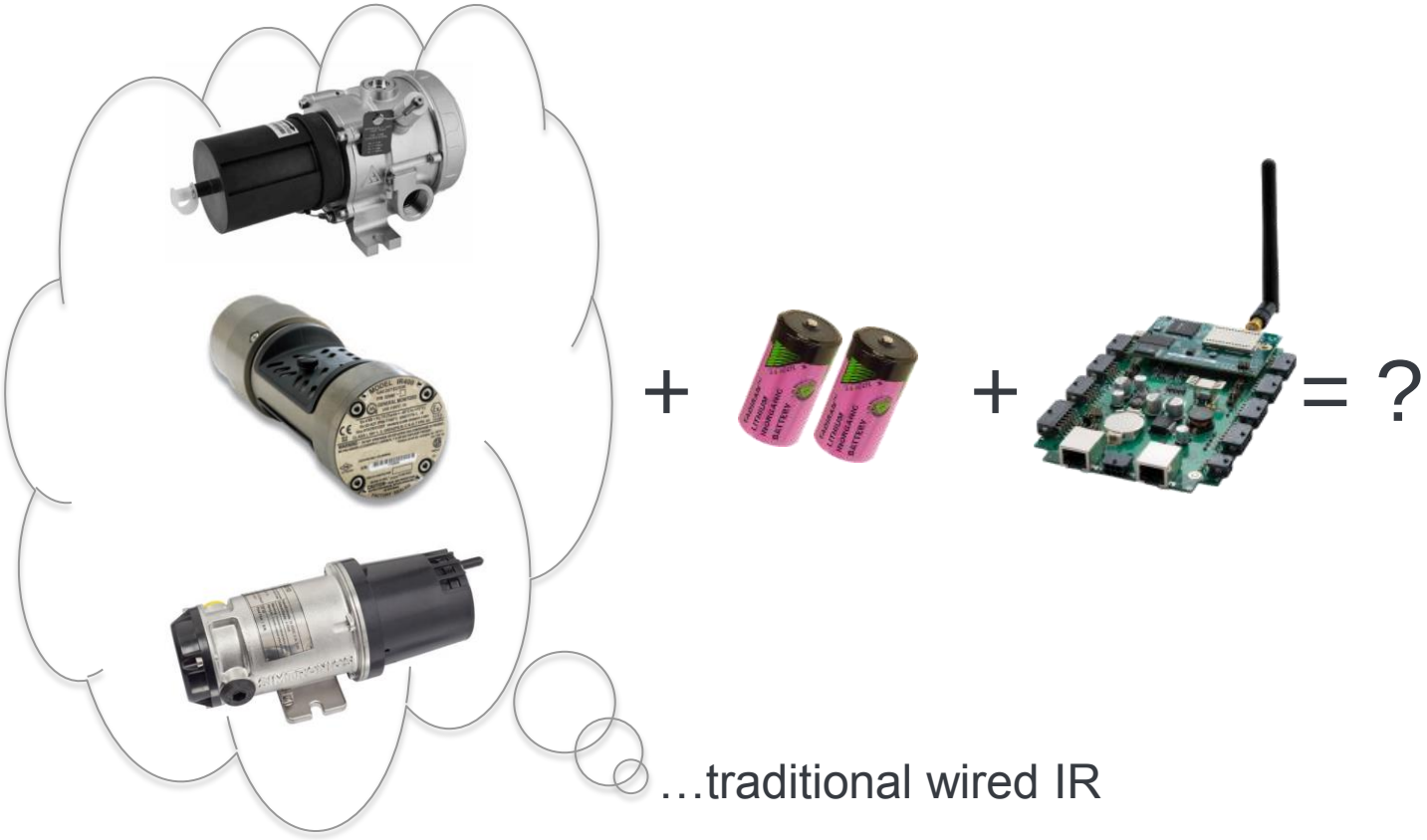


Elephant weight 5000 kg

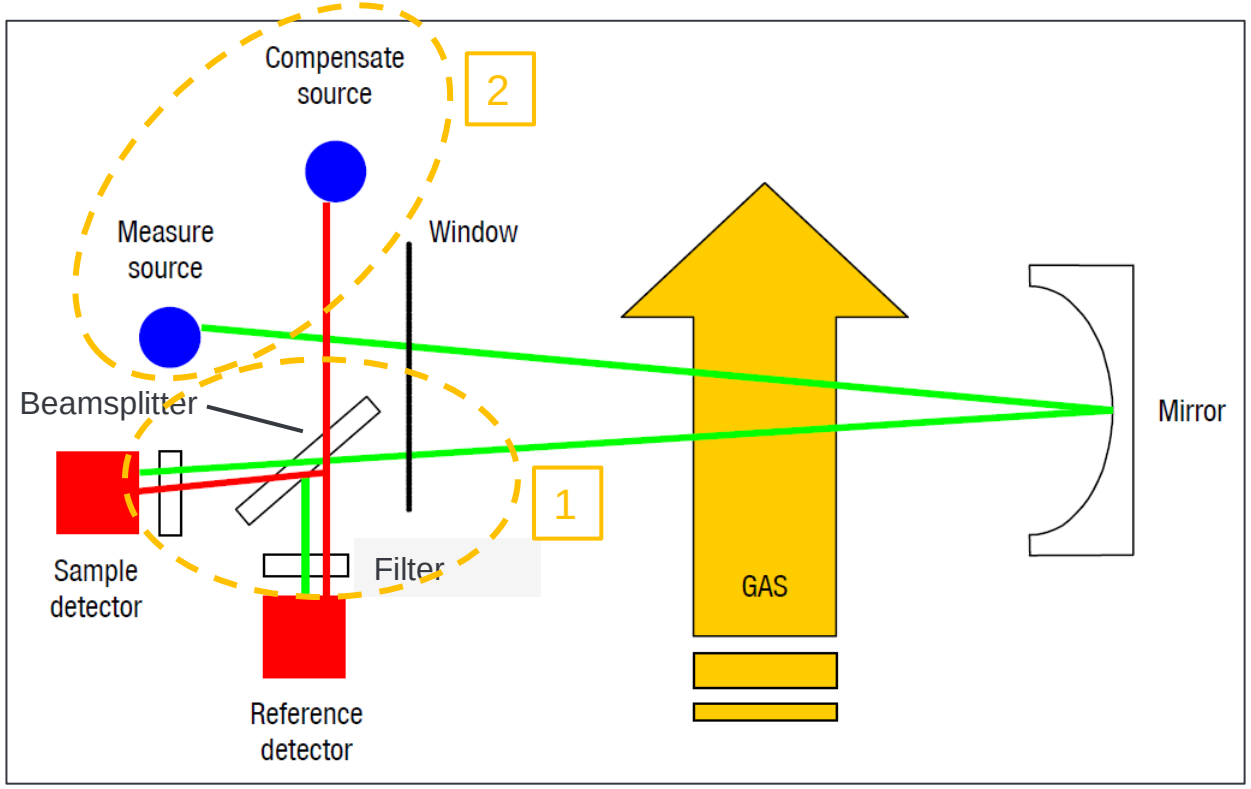
Baby weight 3.5 kg

Traditional Infrared Detectors

The energy consumption is too high to just add batteries and a radio.



Traditional Infrared Detectors



Focused areas for MEMS

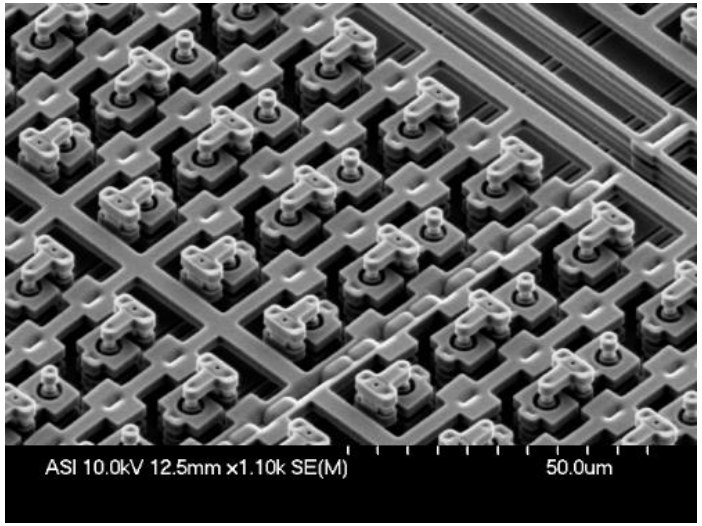
1) Filtering & focusing light on the detection side

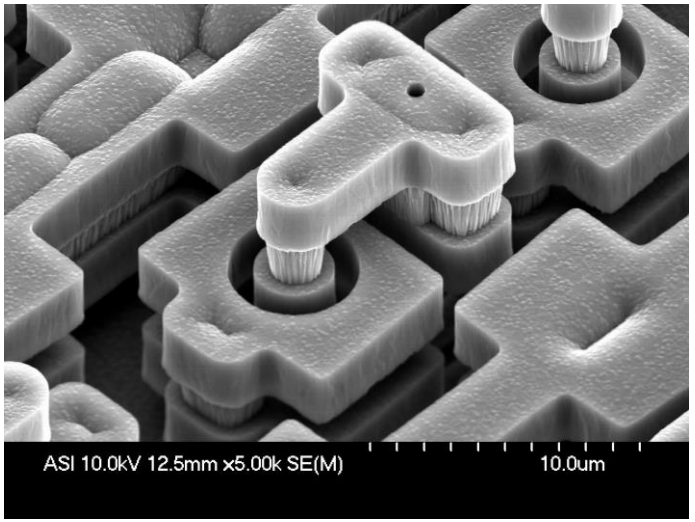
2) Light source

Principal optical design of traditional infrared point detectors

What is MEMS?

- MEMS = Micro Electro Mechanical System
- Technology for integrated microscopic devices
- Electronic and mechanical functions are integrated on the same silicon chip

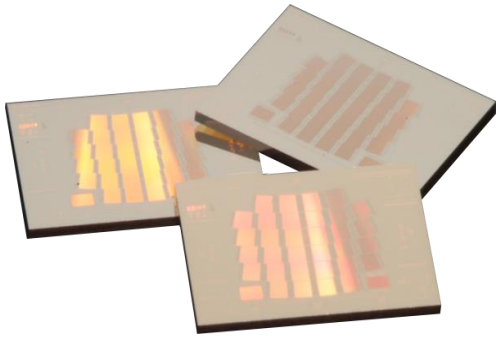




Drivers for MEMS Technology in Gas Detection

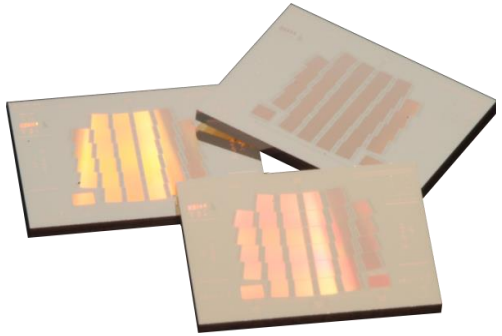
- Long-time stable with no ageing effects
- Compact and low power
- Speed (kHz frequency no problem)
- One chip can serve several purposes

➡ MEMS technology is relevant for the detection side and the source.

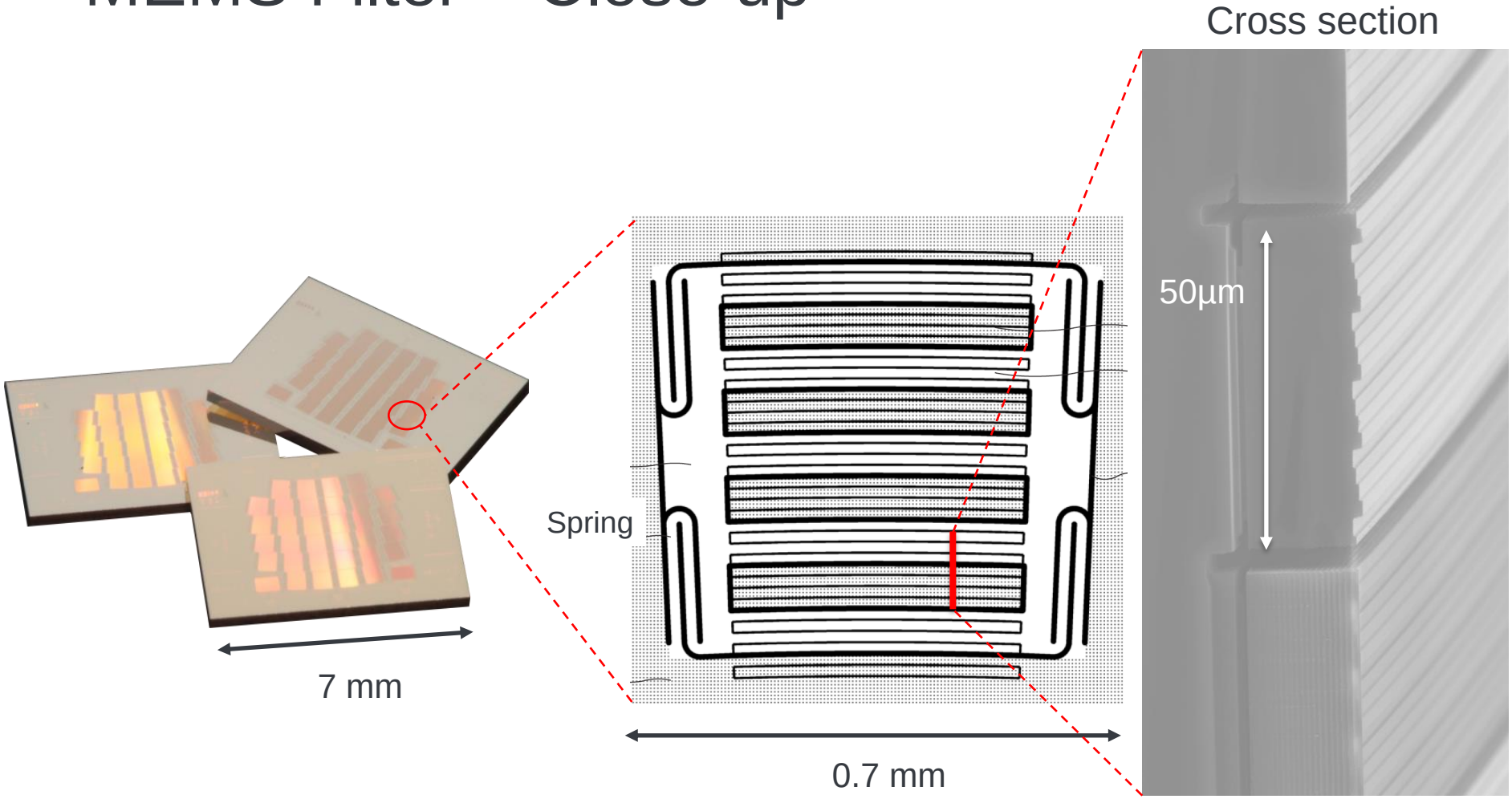


MEMS on the Detection Side

- The GasSecure MEMS filter serves the following purposes
  - Collecting and focusing light
  - Optical filtering
  - Switching between two optical states (gas / reference state)

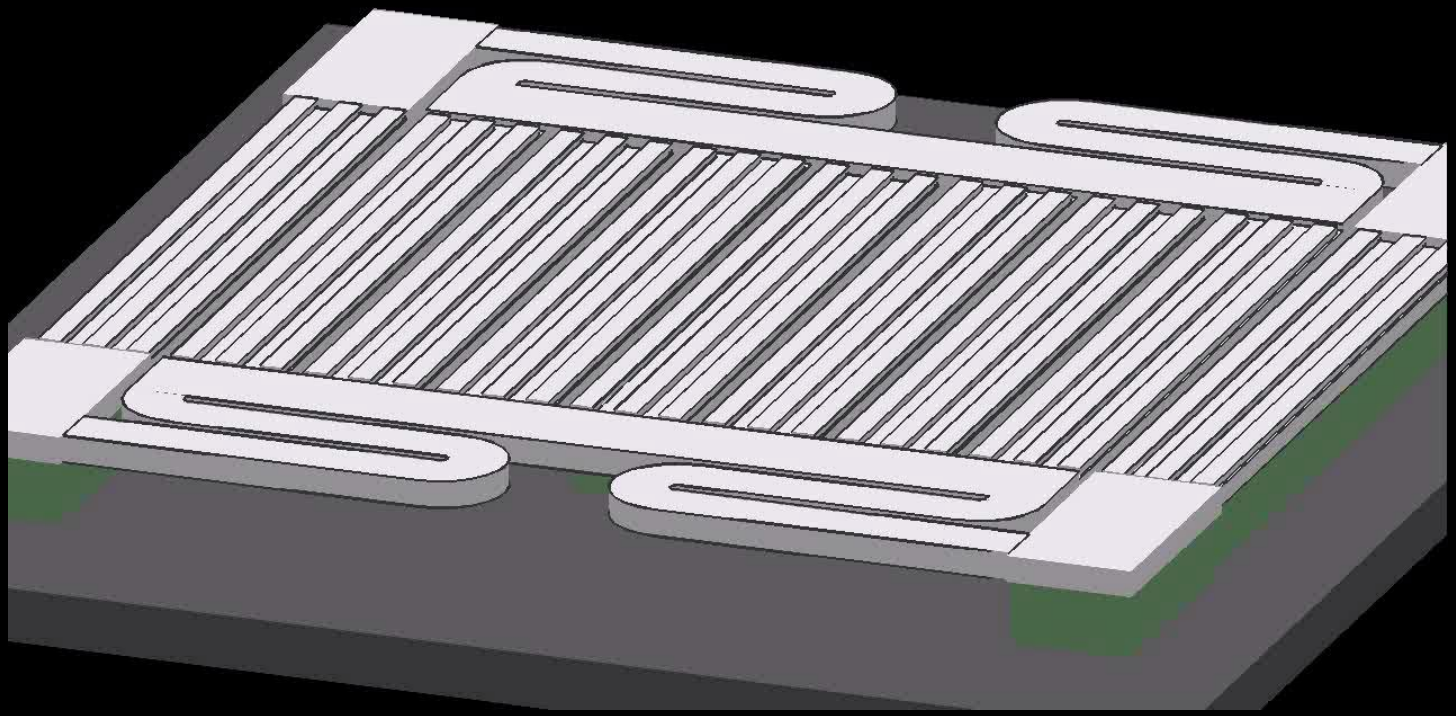


MEMS Filter – Close-up



The MEMS chip consists of fixed and movable micro-gratings that together control the **diffraction pattern** of the infrared beam.

MEMS Chip: Switching Between 2 States

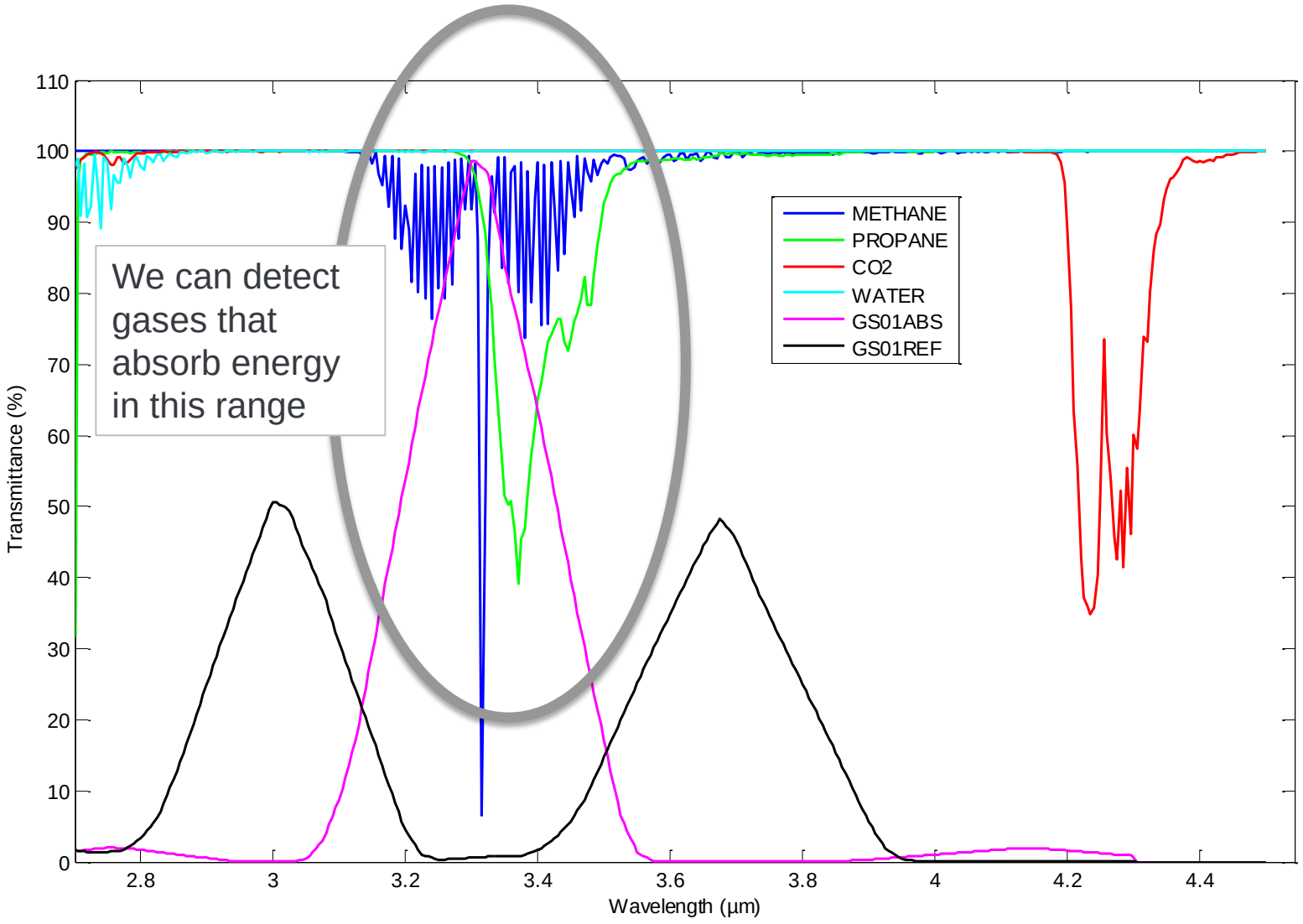


Detection with MEMS

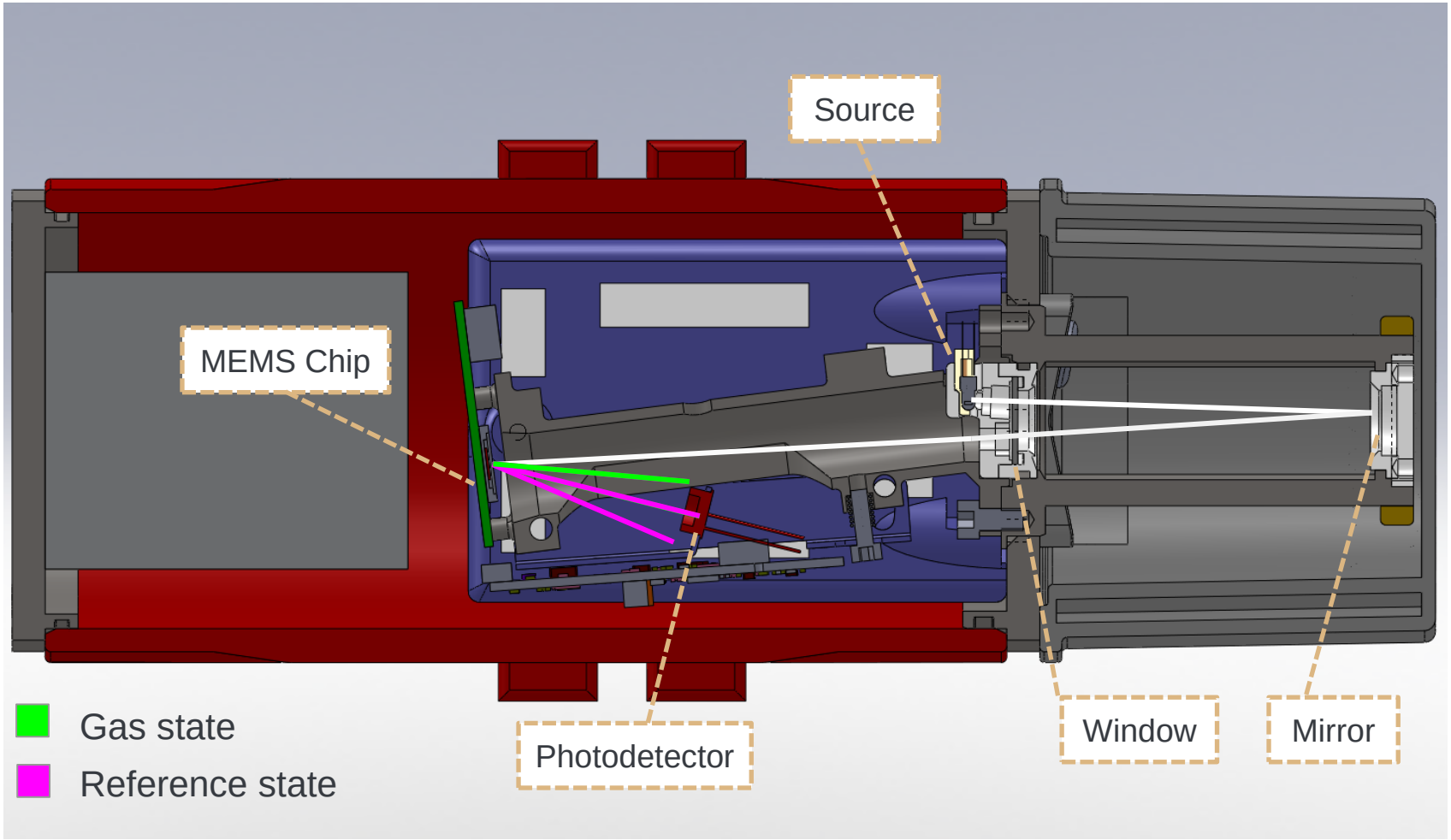
- The MEMS filter switches between
  - Gas state (wavelength where hydrocarbons absorb light)
  - Reference state (wavelength area without HC* absorption)
- Reference state is composed of two spectral areas
- Gas concentration is calculated from ratio of the light intensities in both states
- Reference measurements for ruling out intensity variations not related to gas concentration (e.g. fouling of the window, humidity and condensation)

* HC = Hydrocarbons

MEMS: Optical Filtering at 3.3 µm



MEMS Enables Single-Beam Design



Optical sensor design with MEMS chip

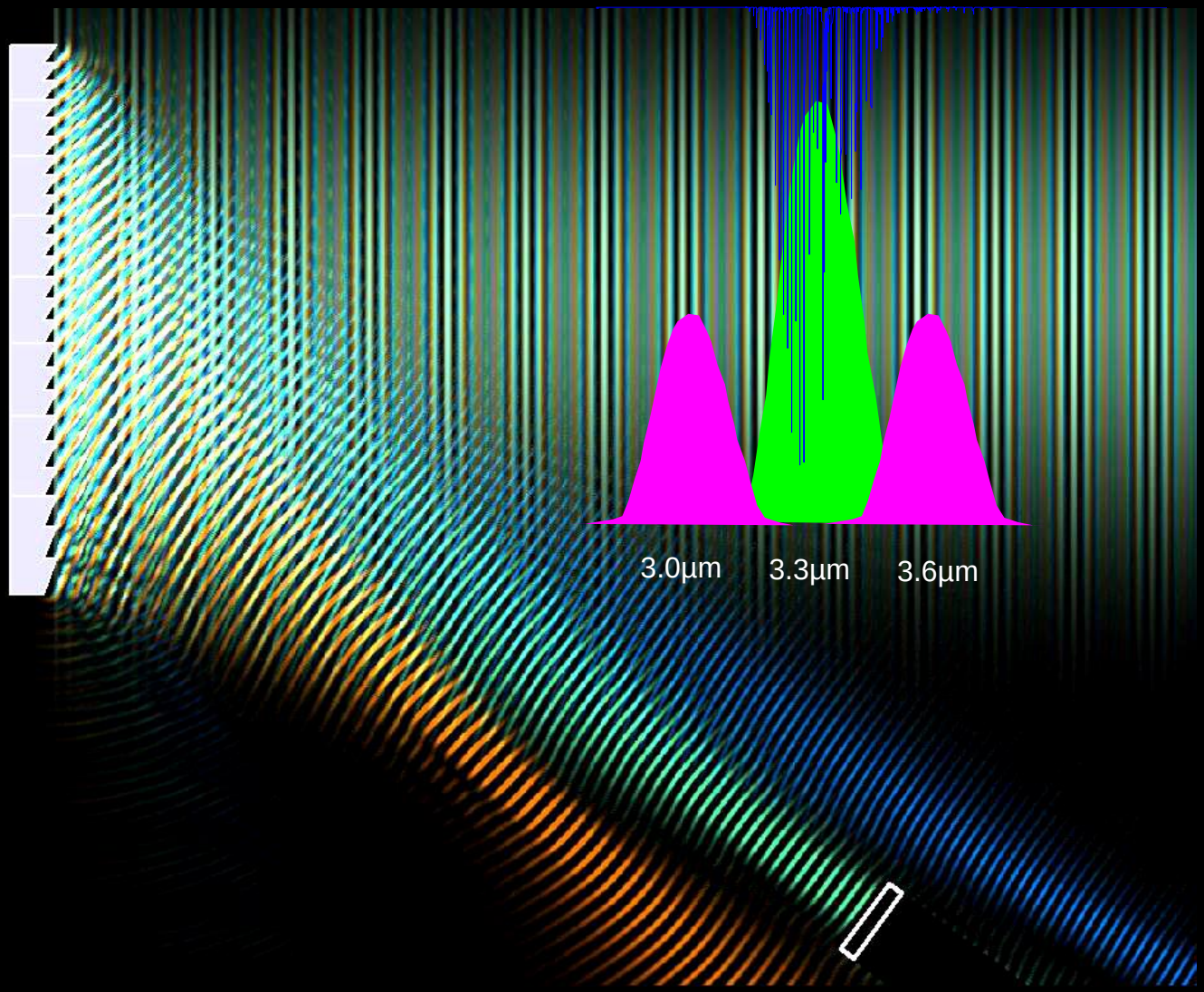
Detection: Single-Beam Design

- The absorption and reference measurement beams follow the same light path.
- One source, one detector, one filter.
- The absorption and reference measurement are virtually taken in the same moment (switching at 1kHz).

⇒ Aging effects of any optical component will not affect the measurement.

⇒ Lifetime calibration for gas detection with MEMS.

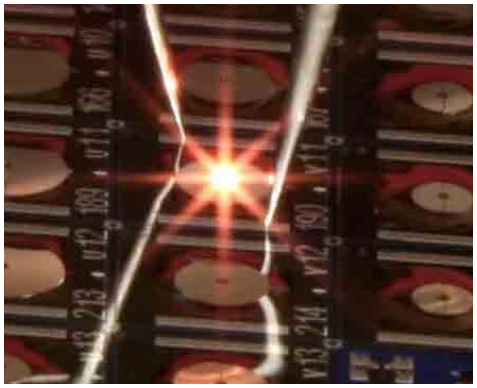
Animation: Switching Gas and Ref. State



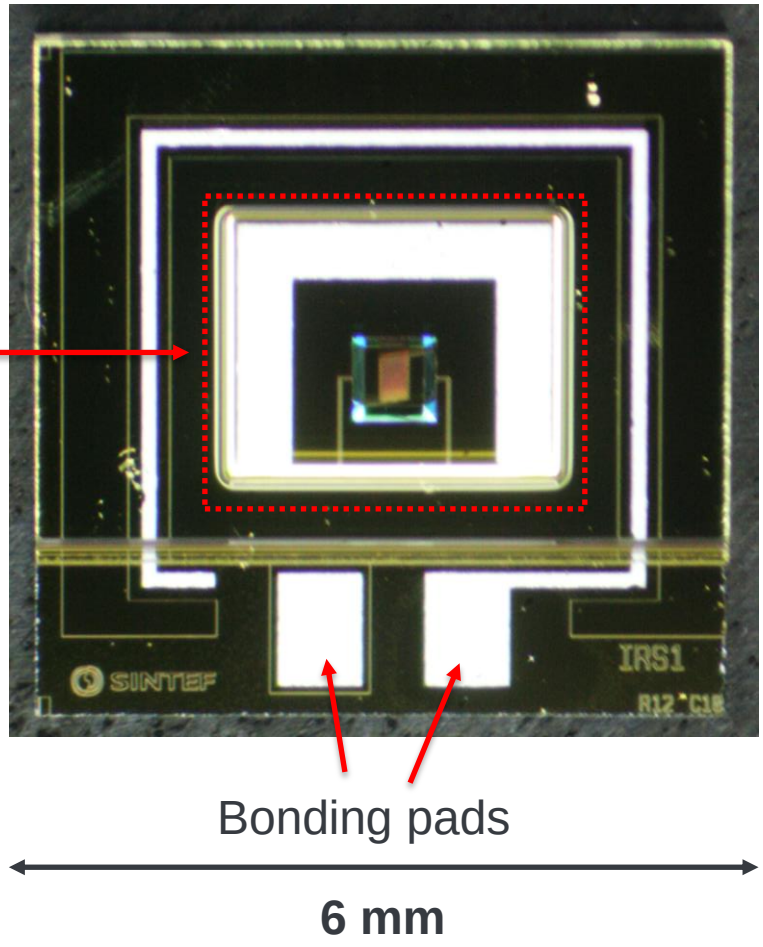
MEMS Used as an Infrared Source

- Typical power of miniature incandescent lamp 100 – 500 mW (not suitable for pulsed operation)
- Typical power of commercial infrared MEMS sources 200 – 1000 mW

- Targeted power of the GasSecure MEMS source = **20 mW**
- Average power consumption is further improved by the excellent pulse mode capability of our source



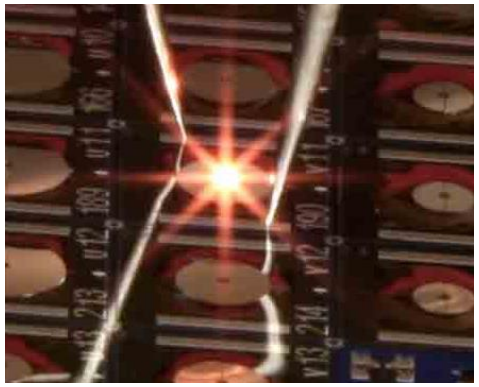
GasSecure MEMS Source Close-up



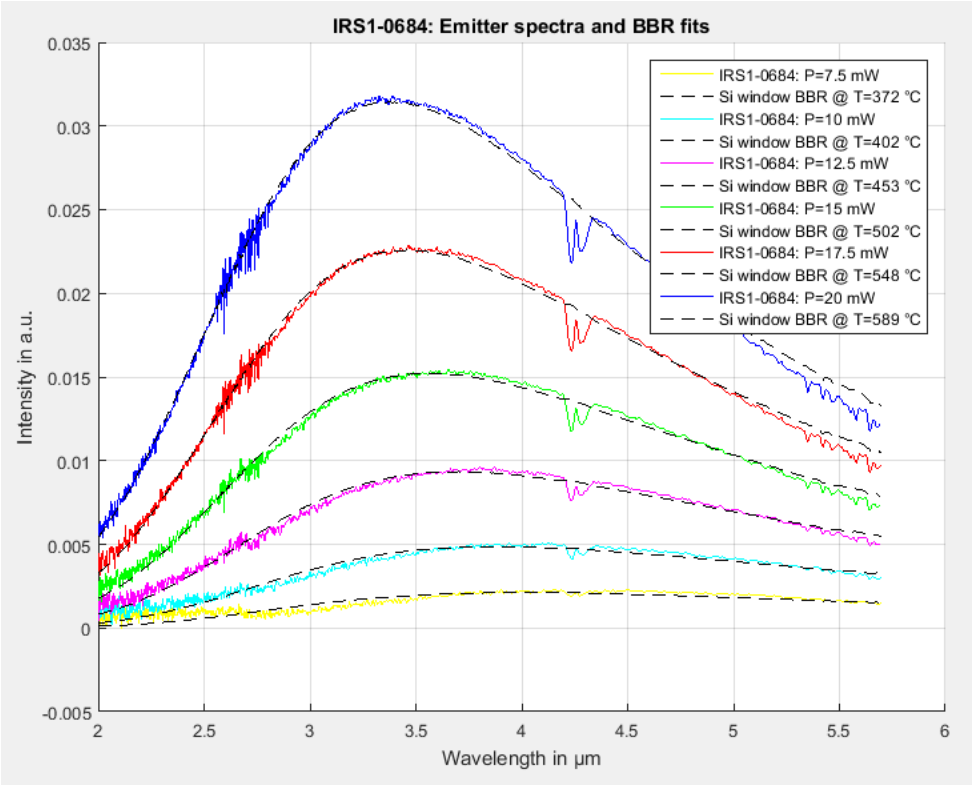
- Micrometre-scale filament
  - ➡ Low thermal mass
- Suspended filament in vacuum cavity
  - ➡ Low thermal conductivity
- Low thermal mass and conductivity enable highly efficient pulsed operation.

GasSecure MEMS Source Operation

- Filament heated by driving current through it until it glows
- Typical operation is a 2% duty cycle
- About 20 mW input power
- Emitter temperature of around 700 ^{o}C



MEMS Source Emission Spectrum



– The emission spectrum is optimized for hydrocarbon gas detection with an intensity peak at 3.3 µm.

MEMS Source – Lifetime Tests

- Lifetime depends on source temperature and on-time
- Tests confirm source temperatures suitable for gas detection are compatible with acceptable lifetime

- Accelerated testing:
  - 50% duty cycle → 25x acceleration factor
- Emitters operated in accelerated mode for more than 16 months
- Expectation: > 20 years in typical operation

From MEMS technology to Real Product...

GS01 - Wireless infrared hydrocarbon gas detector

<u>Key Features</u>:

- Reliable IR technology
- Fast response (5s)
- SIL2, incl. communication
- Up to 2 years battery life
- Intrinsically safe
- Field replaceable battery pack
- No recalibration required

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Thank you for your attention!
Any questions?

GasSecure AS
Hoffsveien 70 C
0377 Oslo, Norway
www.gassecure.com