Microelectromechanical systems (MEMS) for photoacoustic gas spectroccopy

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1. Goal

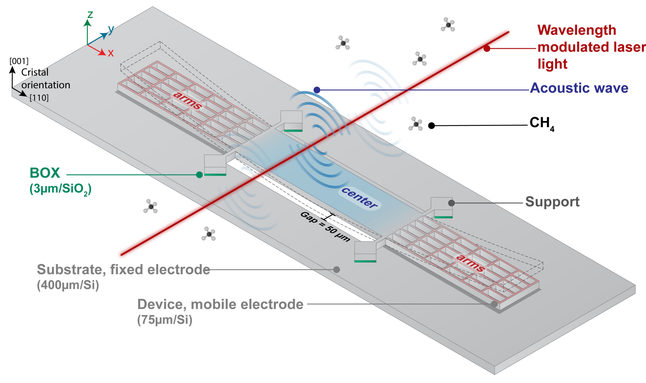
Our goal is to make a technological breakthrough to develop a compact, ultra-sensitive and selective photo-acoustic gas sensor. We aim to reach and exceed the highest performances among photoacoustic techniques. Based on electrical transduction, the sensors will be more compact and versatile than the current best technology based on optical transduction. This project addresses the demand for a real-time, multigas detector used for diagnostic purposes by measuring exhaled air or monitoring atmospheric pollution, among other potential applications.

medical diagnostic based on breath analysis

measurement of atmospheric pollution

2. Working principle

1) A laser source emits a light beam that passes through a cell containing the target gas.
2) When the laser is absorbed by the target gas, it creates a local thermal expansion that generates an acoustic wave.
3) The acoustic wave is detected by a mechanical resonator and converted into an electrical signal.
4) By analyzing the amplitude of this signal, it is possible to determine the concentration of the target gas.



3. Modeling

Quality factor

- viscous damping and squeeze film effect; thermoelastic damping; acoustic losses; support losses

Photoacoustic wave generation

- Gaussian beam
- Wave equation with source therm
- Thermal relaxation time
- Photoacoustic force F_{PA}

Mechanical movement

- Susceptibility $\chi(\omega)$
- Displacement W_n
- Euler-Bernoulli beam theory

Electrical signal and performance

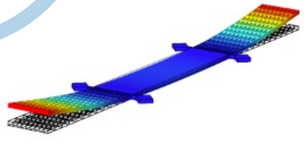
- Voltage output V_{out}
- Signal-to-noise ratio SNR

Implemented in Python programming environment

python

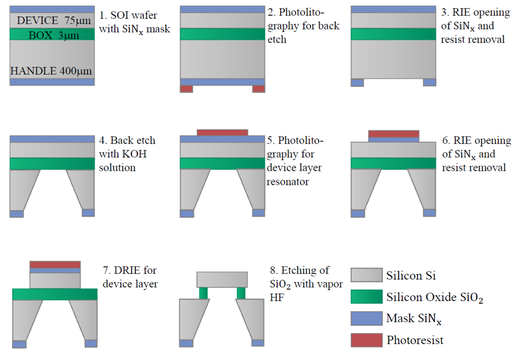
and finite element software

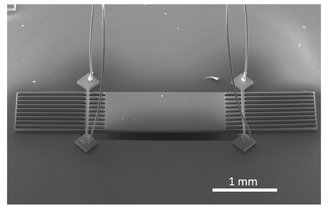
COMSOL MULTIPHYSICS



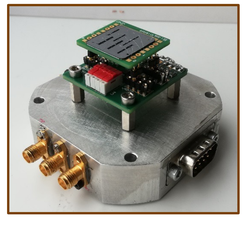
4. Fabrication

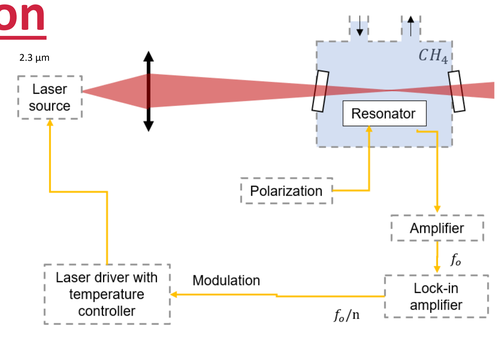
The entire fabrication process will be carried out in the clean room facility situated at the IES laboratory of the university.

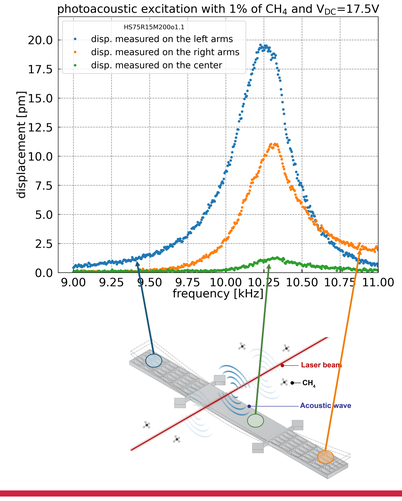


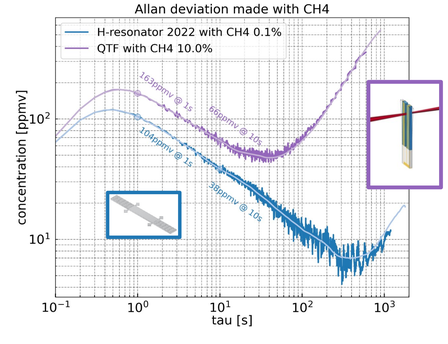


5. Characterization









	NNEA ($W.cm^{-1}.Hz^{-1/2}$)
H-resonator (2022)	$8.6 \cdot 10^{-8}$
Bare QEPAS (2021)	$1.3 \cdot 10^{-7}$