Reducing Food Waste With a Tiny CMOS-MEMS Gas Sensor, Dubbed GMOS

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Motivation

Up to 50% of fruits and vegetables

are wasted[1]

There are huge efforts to reduce it

[1] FAO. (2011). Food Loss and Food Waste - Extent Causes and Prevention. Rome

Research Questions

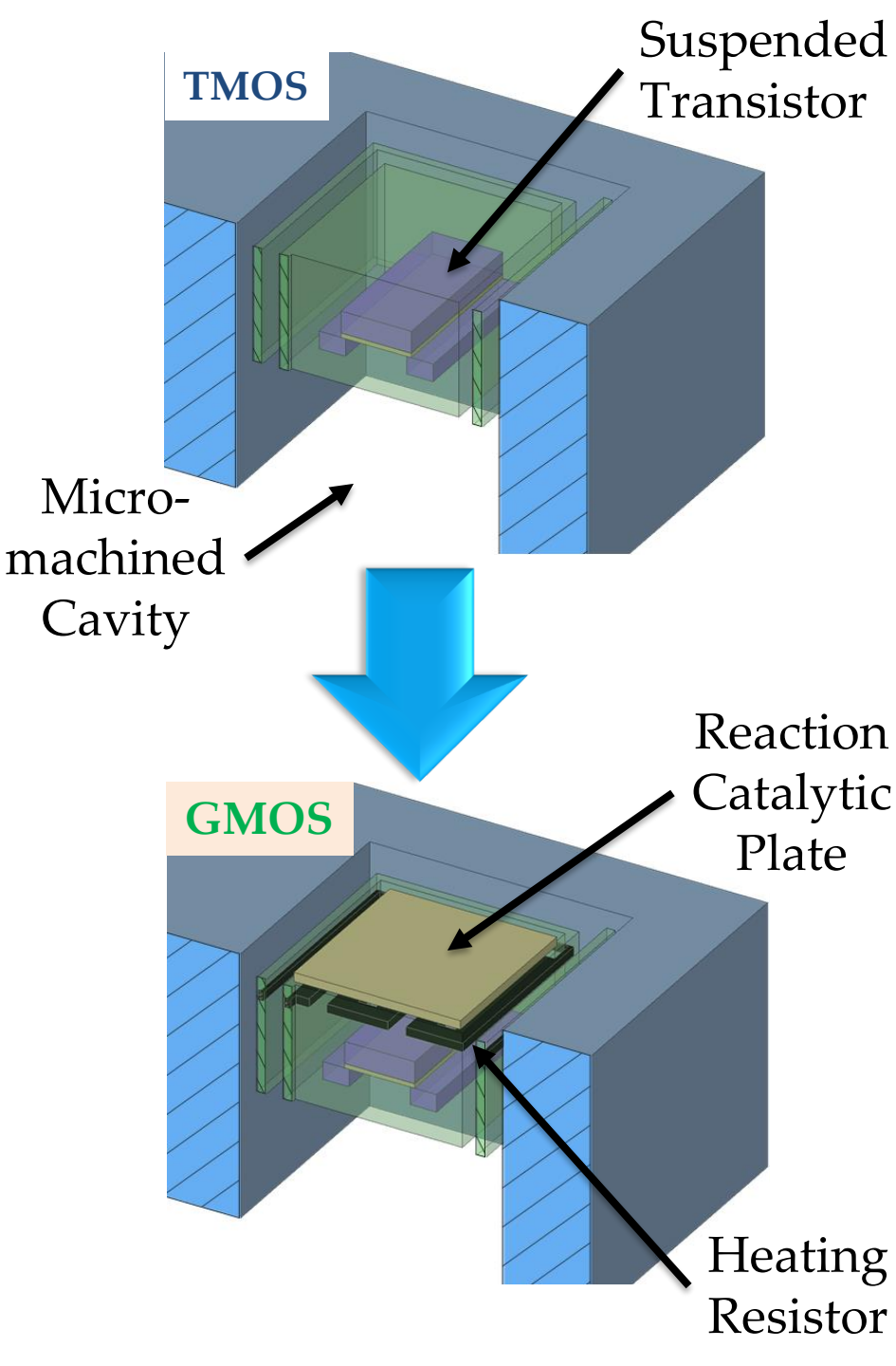
Q1: How is it possible to reduce the food loss?

A1: Ethylene gas is a ripening plant hormone

Q2: What are the problems with ethylene monitoring?

A2: Detection system size, price, sensitivity and selectivity

Q3: How to solve these problems?



Innovation

- **TMOS thermal sensor is invented at Technion**
- **It is high performance miniature thermal sensor**
  - ✓ Achieved using CMOS-SOI-MEMS process
- **It is uncooled Infrared sensor**
  - ✓ Suspended transistor detects temperature changes induced by IR radiation
- **TMOS characteristics are:**
  - ✓ Highest temperature sensitivity
  - ✓ Low power consumption
  - ✓ Low cost fabrication
- **TMOS advantages applied to fabricate gas sensor**

GMOS

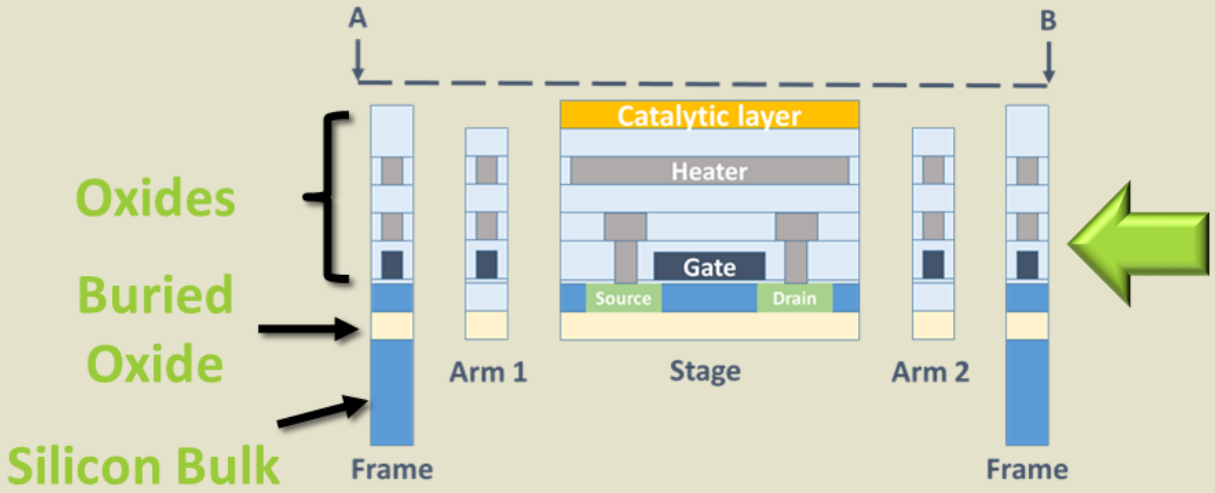
GAS — **MOSFET**

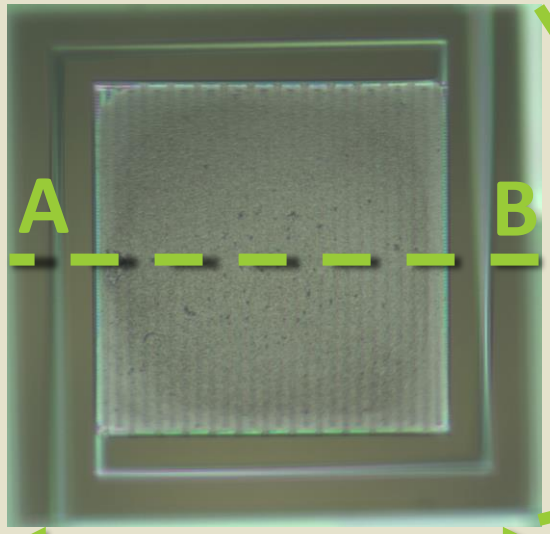
The sensing element

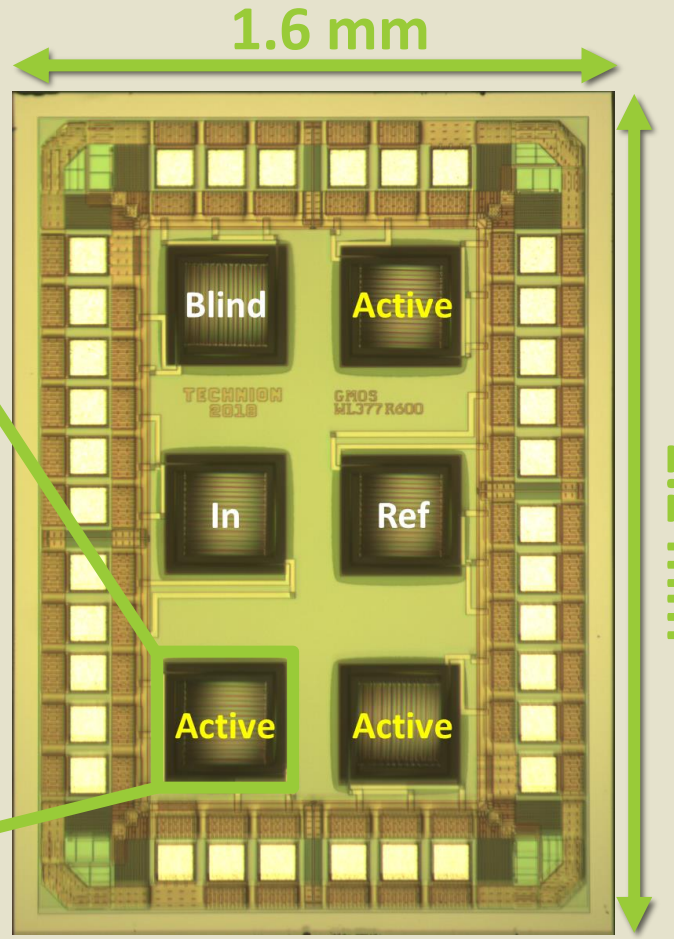
GMOS Principle

Miniature Combustion Type Gas Sensor

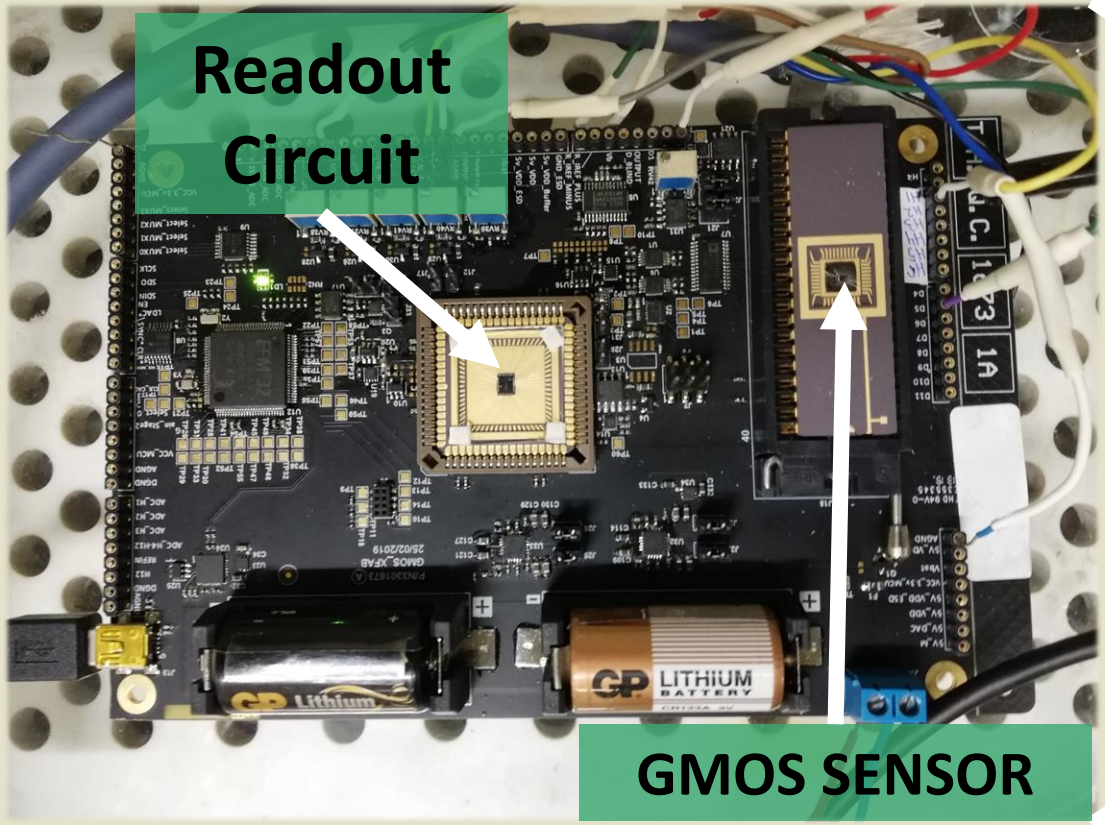
- Heating with built-in resistor to gas ignition temperature
- Combustion reaction releases heat which increases TMOS temperature and modifies the current-voltage characteristics



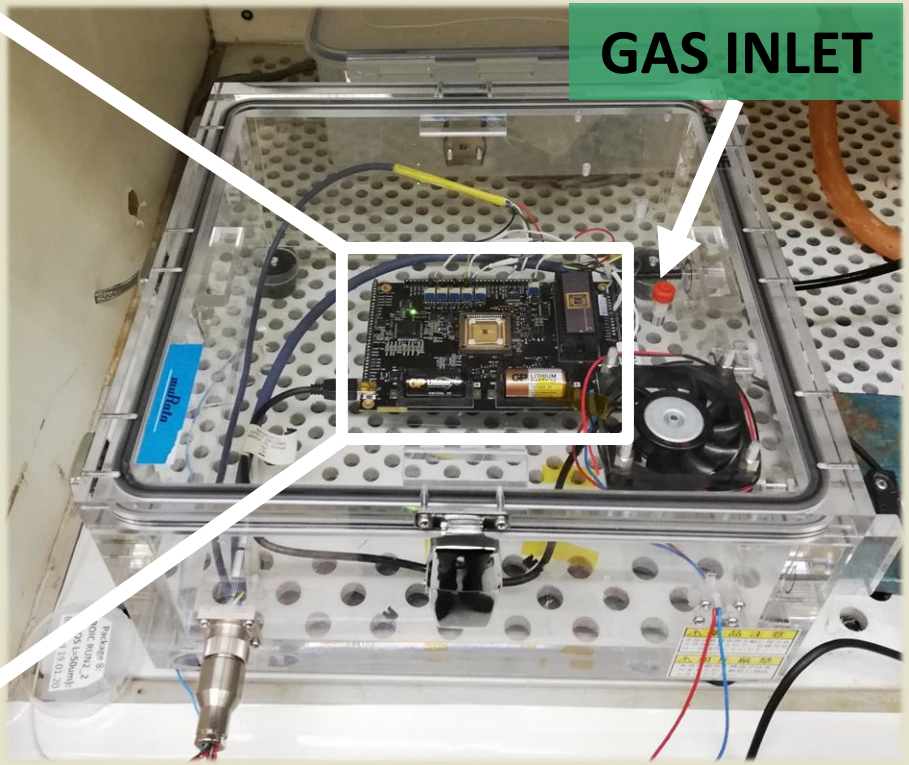




Experimental Setup



Evaluation Board

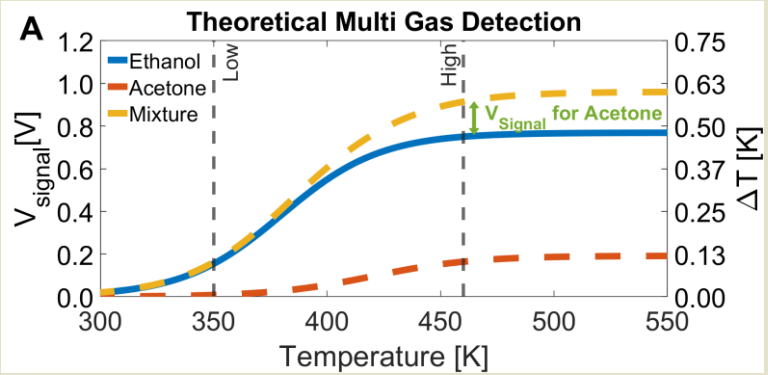


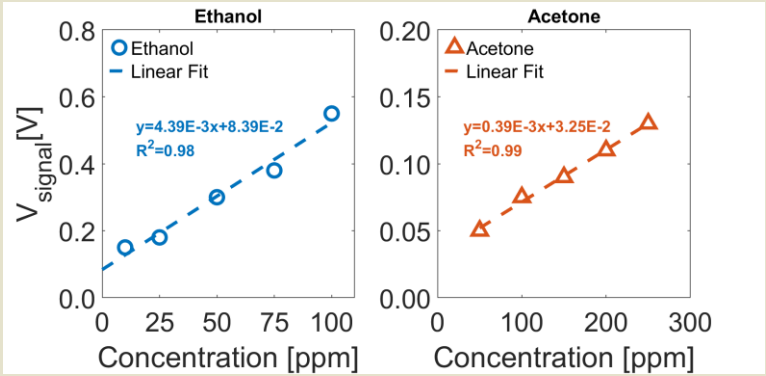
Gas Chamber

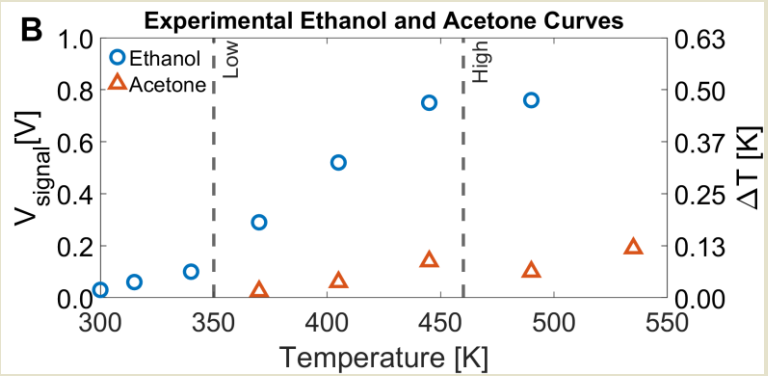
Multi-Gas Sensing

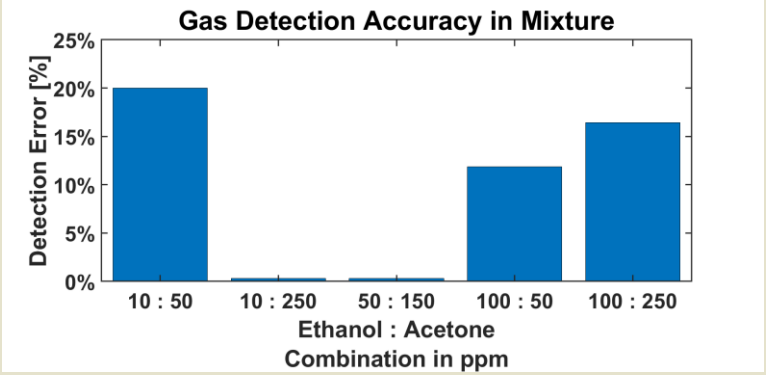
Selectivity Term – Ignition Temperature, *T**

Selectivity Demonstration with sputtered Pt Catalytic Layer









- At low temperature only ethanol can be detected, and the signal is needed to predict the signal at high temperature
- For simplicity, the signal-concentration curves are shown at high temperature only, for ethanol and acetone
- Experimental error between signal in mixture and sum signal of both gases

Selective Ethylene Detection

Using Pt and TiO_2 Catalysts

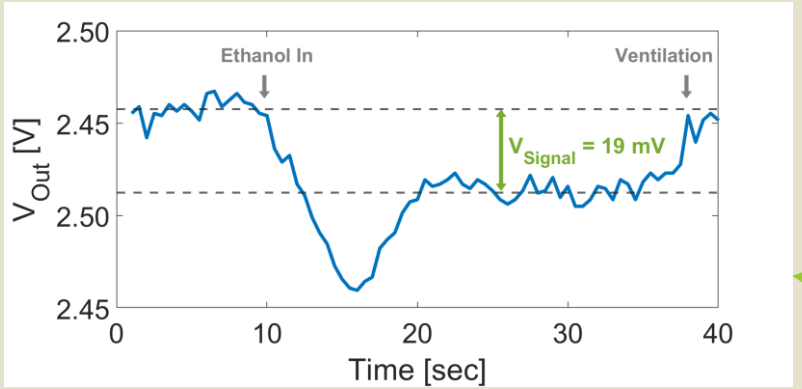
GMOS may be tailored for application by catalyst selection:

TiO_2 – for **High** concentrations (100 – 300 ppm)

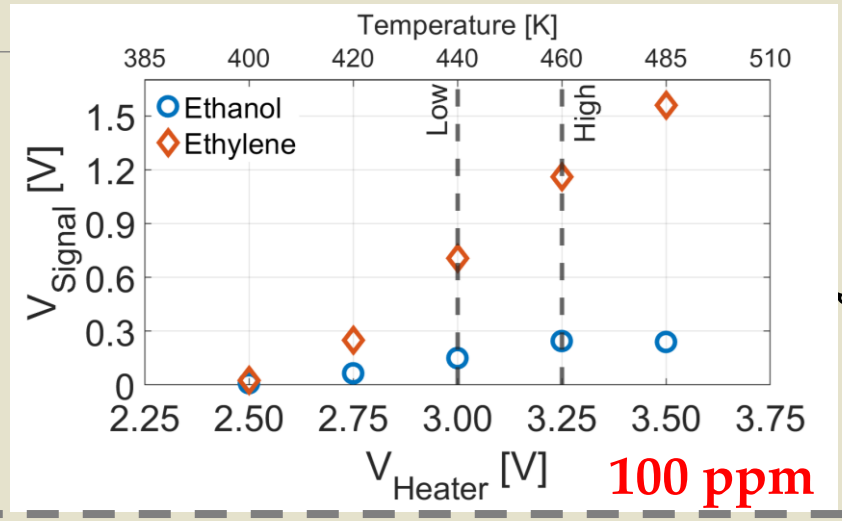
Pt nanoparticle – for **Low** concentrations (1 – 10 ppm)

- **High ethylene** concentrations are monitored in ripening rooms

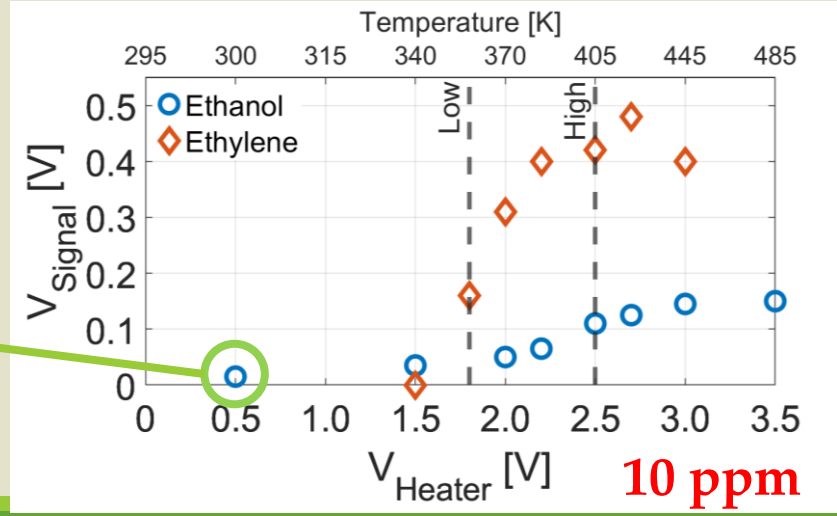
- **Low ethylene** concentrations are monitored during fruits storage and transportation processes



TiO_2 Catalyst



Pt Nanoparticle Catalyst



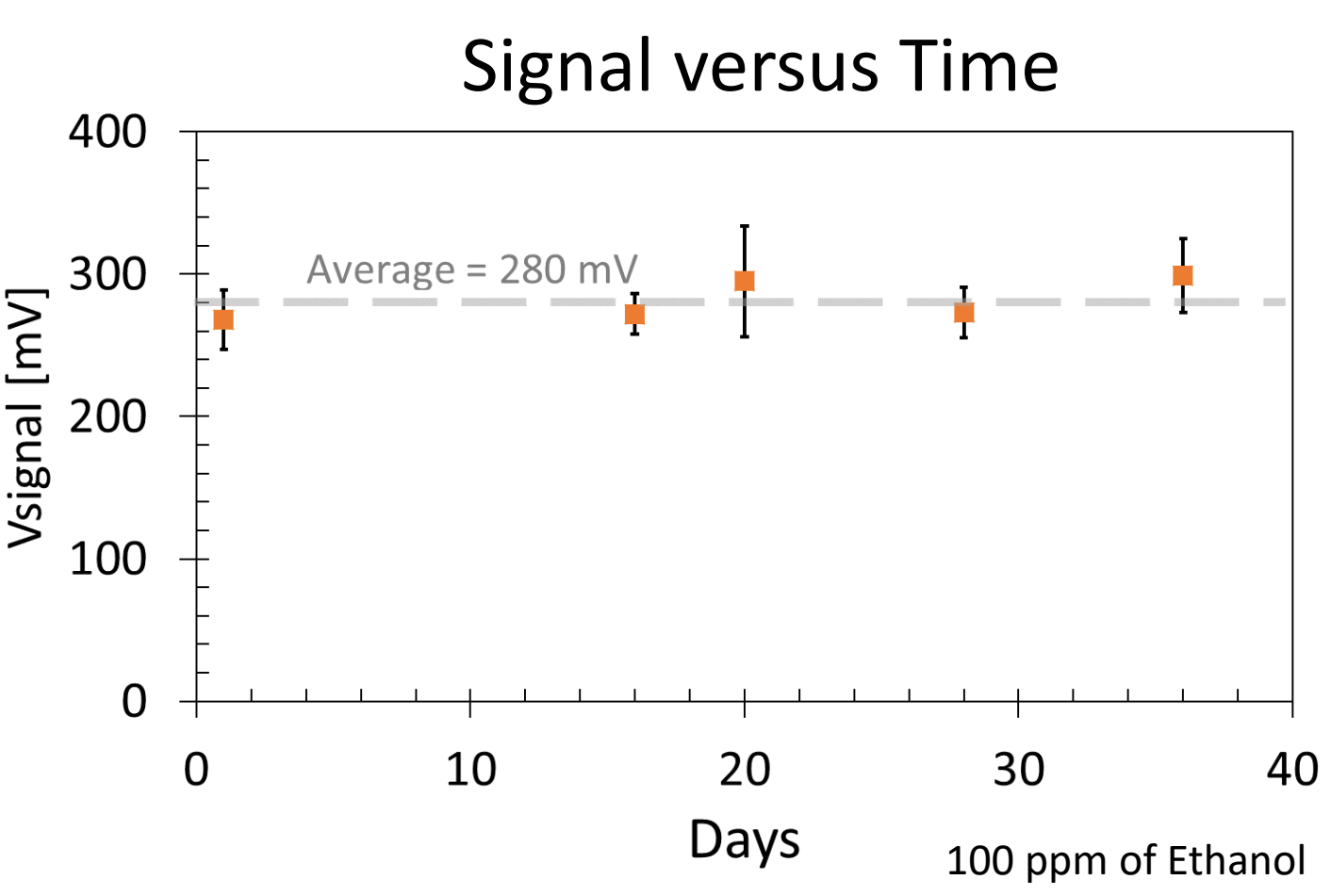
GMOS Reliability

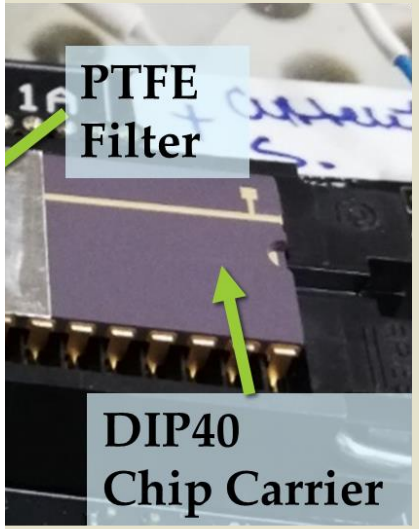
Methods to Improve Signal Stability Over Time

Catalyti

pre-heating

aging





Removing or

contamination

from the

catalytic surface

Summary

GMOS is:

✓ Tiny	Area: 1.6 x 2.2 mm^2
✓ Cheap	Few $/unit
✓ Requires Low Power	As much as 1 mW
✓ Sensitive	Up to 45 mV/ppm
✓ Selective	Using ignition temperature
✓ Reliable	Using standard technology and tested procedures

Promising technology for future gas sensing applications

Acknowledgements

The generous funding of TODOS TECHNOLOGIES Ltd.

(https://www.todos-technologies.com) is gratefully acknowledged.

TODOS TECHNOLOGIES holds exclusively the IP related to this work.