European Network on New Sensing Technologies for Air Pollution Control and Environmental Sustainability - *EuNetAir*

COST Action TD1105

WGs and MC Meeting at ISTANBUL, 3-5 December 2014

Action Start date: 01/07/2012 - Action End date: 30/06/2016

Year 3: 1 July 2014 - 30 June 2015 (*Ongoing Action*)

PARTICLE DETECTION USING ACOUSTIC WAVE TECHNOLOGY FOR AIR QUALITY MONITORING

Microsensors and Bioelectronics Laboratory

Farah H. Villa López, S. Thomas, M. Cole and J.W. Gardner

Microsensors and Bioelectronics Laboratory

The University of Warwick / United Kingdom

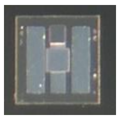
COST is supported by the EU Framework Programme

ESF provides the COST Office through a European Commission contract

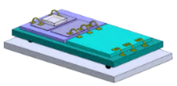
OVERVIEW

Introduction: Air pollution, acoustic wave technology

Description of the system: Solidly Mounted Resonators (SMRs), particle sensing unit.



Preliminary Results: particle testing.



Conclusions and further work

Introduction – Air Pollution

- Human Exposure to air pollution is considered especially hazardous for human health.
- There is a need of taking measures to reduce the concentration of air pollutants.
- Concentration limits and target values of different pollutants are established by the World Health organisation air quality guidelines and EU regulations.

Introduction – Particulate Matter

- **Target Parameter:** Particulate Matter.

  - Mixture of chemicals in the form of very fine particles that can be found in the air.

PM10	Diameter <10 µm
PM2.5	Diameter <2.5 µm
UFPs	Diameter <100 nm

Introduction – Particulate Matter

- Respiratory problems
- Cardiovascular diseases

→ Increase of mortality and morbidity rates

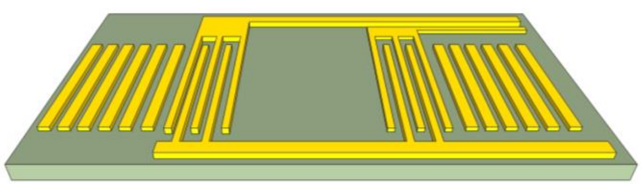
It is important to develop low cost and portable devices for particle detection and air quality monitoring.

Introduction – Acoustic Wave based devices

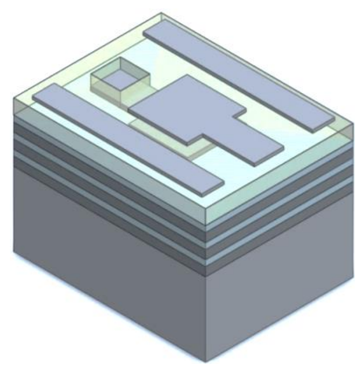
- **Operating Principle:** Reverse and Direct Piezoelectric Effect.

Reverse – Electric potential to Mechanical deformation
Direct – Mechanical deformation to electric potential

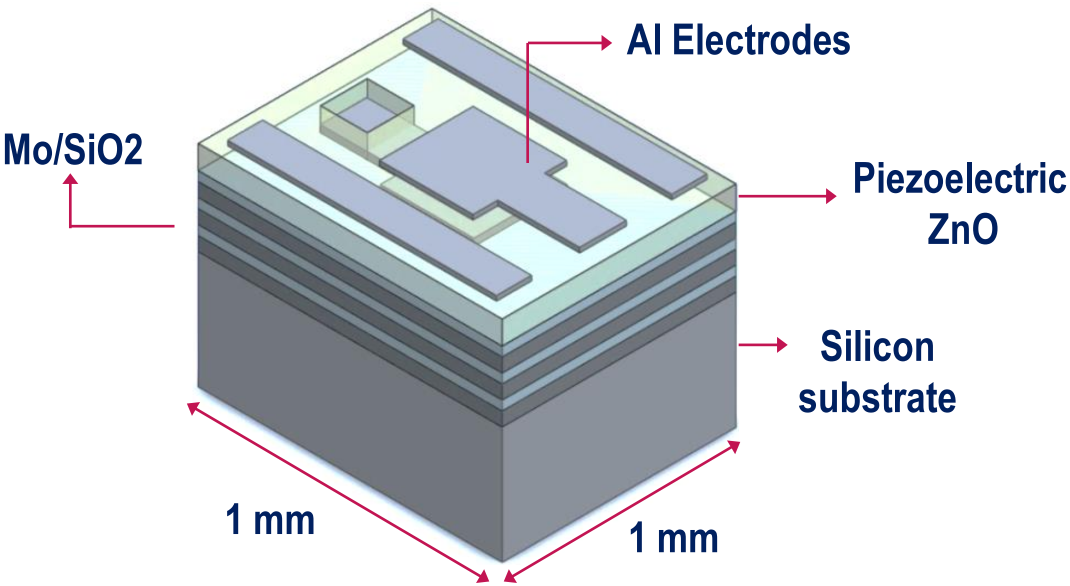
SAWR
Surface Acoustic Wave Resonator



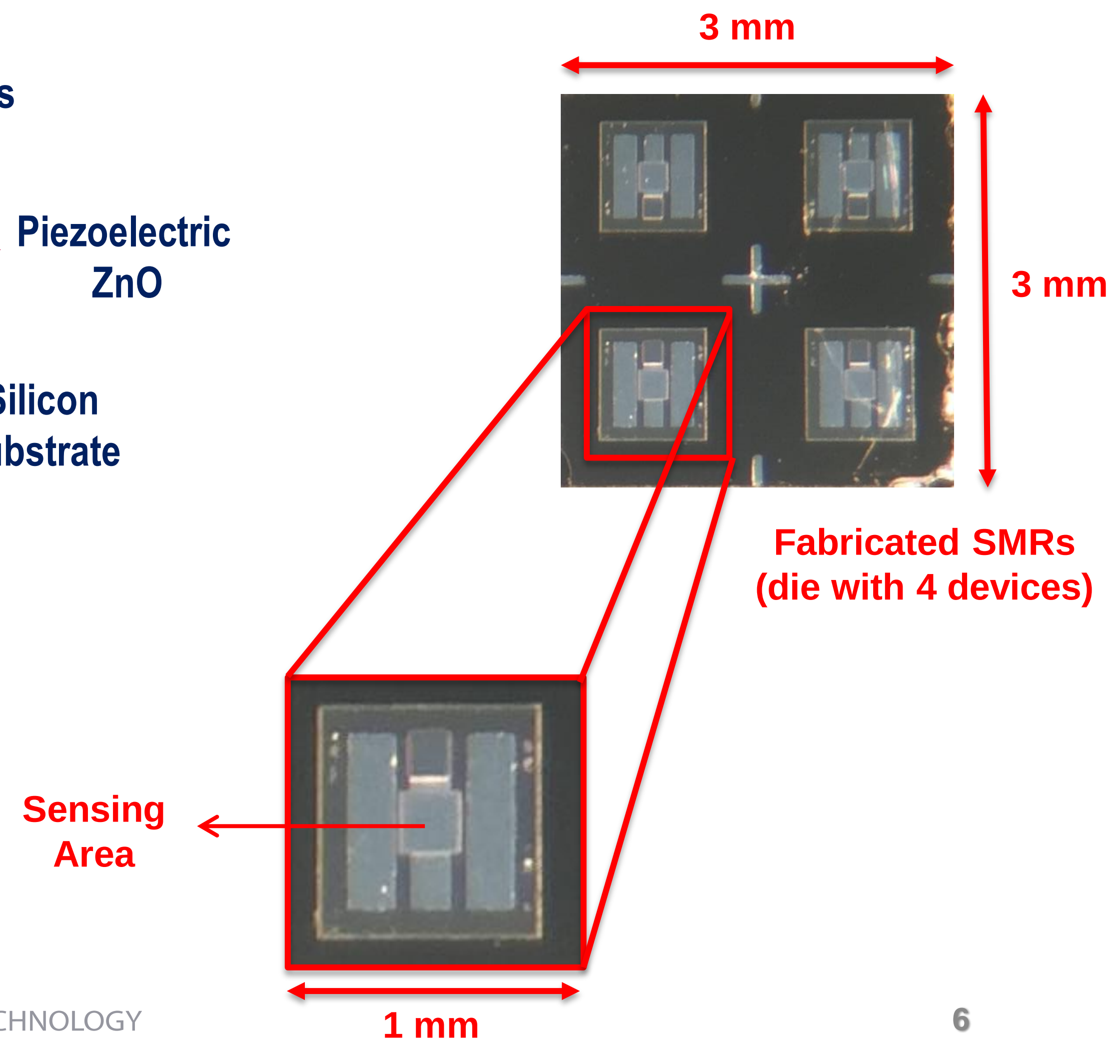
SMR
Solidly Mounted Resonator



Description of the system – Solidly Mounted Resonator



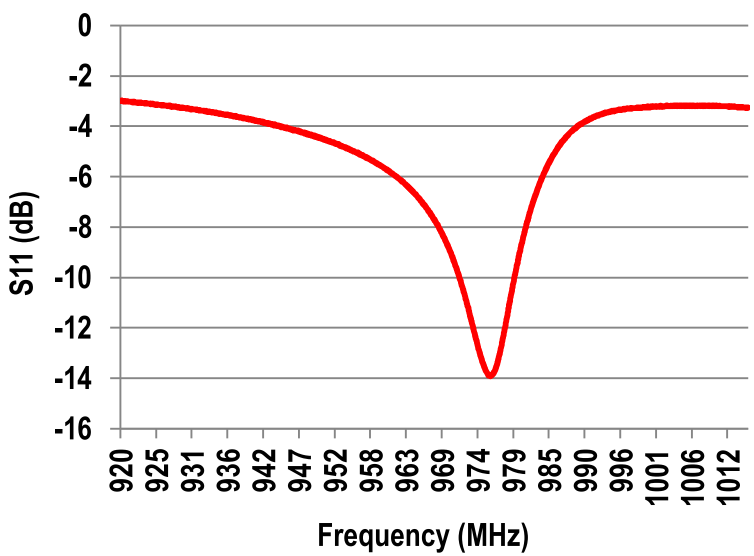
Schematic of the SMR

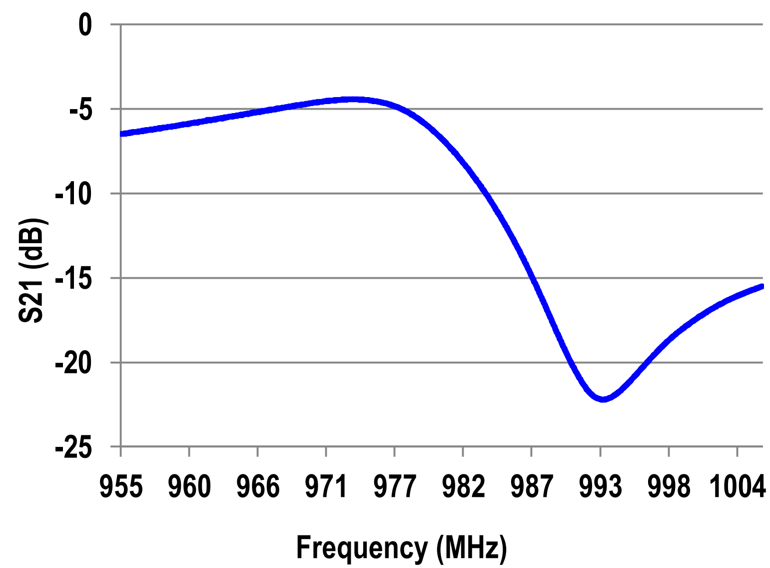


Fabricated SMRs (die with 4 devices)

Description of the system – Solidly Mounted Resonator characterisation

Scattering Parameters

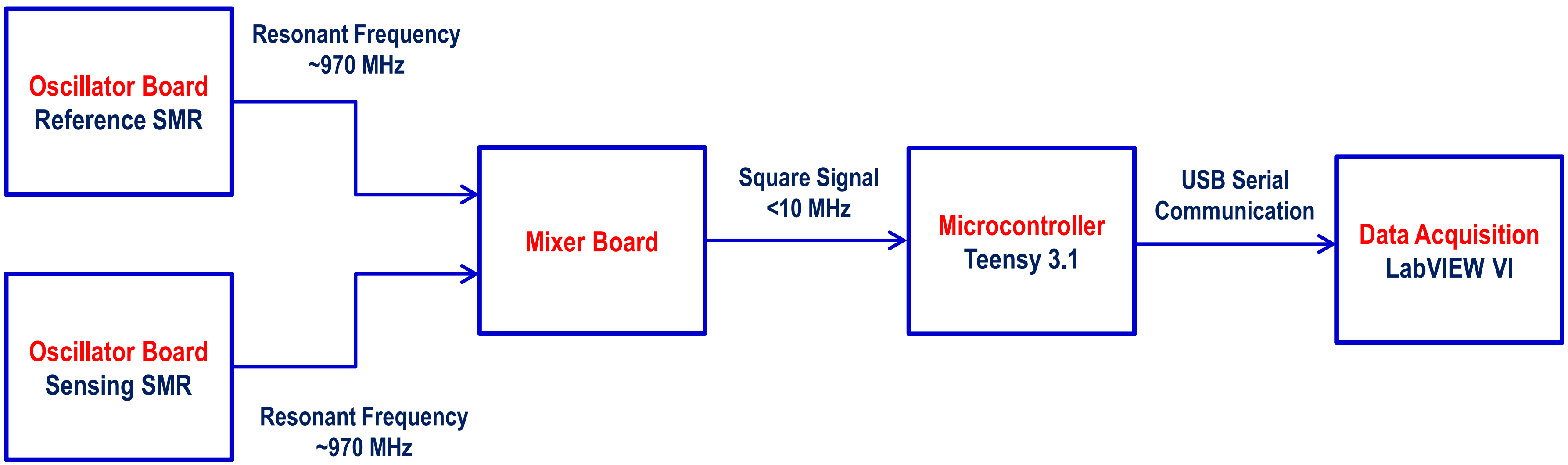




Resonant frequency = ~970 MHz

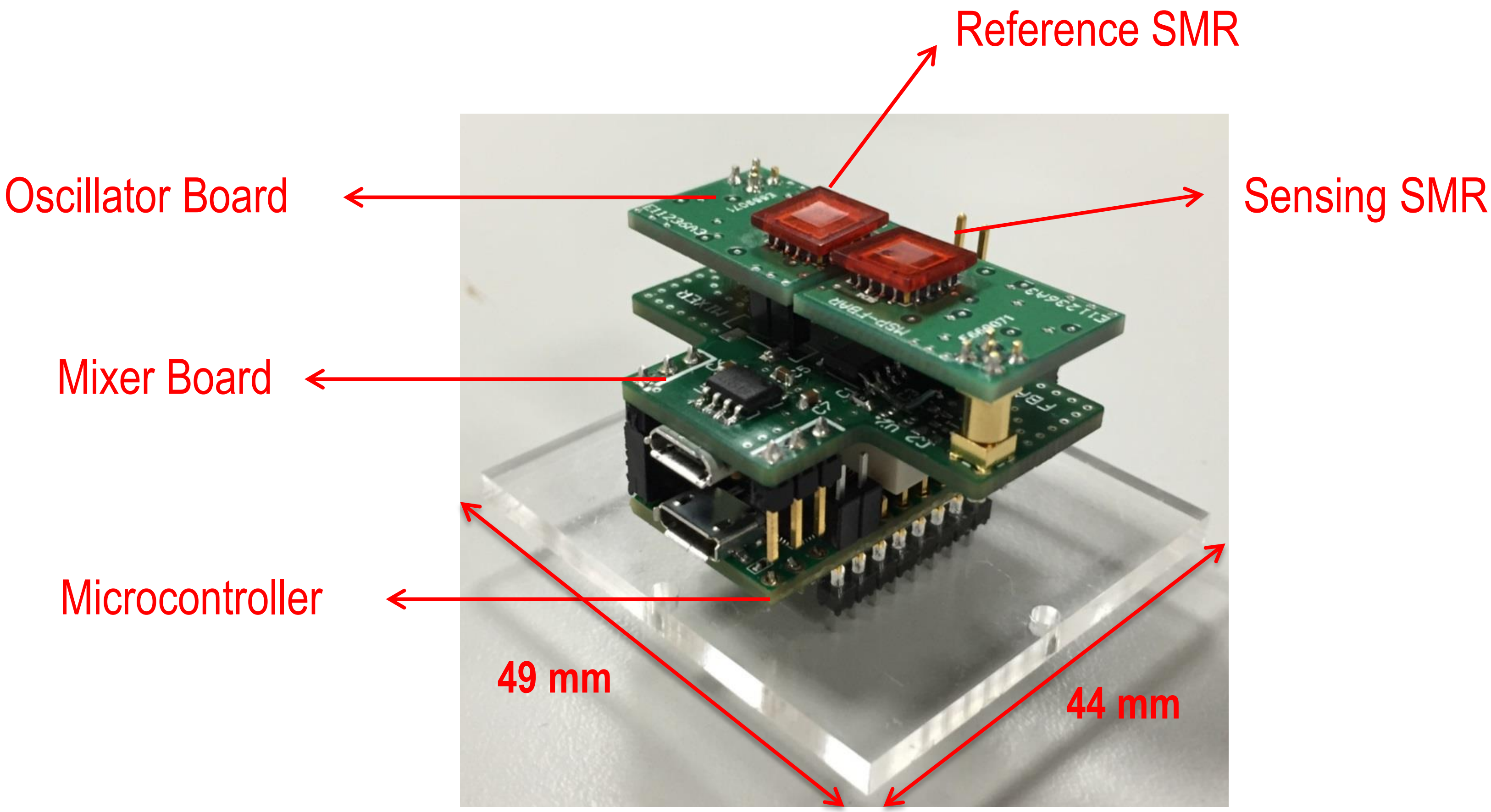
Description of the system – Overall structure

- Particle sensing system operates in a dual configuration.
- The SMR devices are driven by a Colpitts type oscillator circuit.



Description of the system –

Particle Sensing Unit



Description of the system –

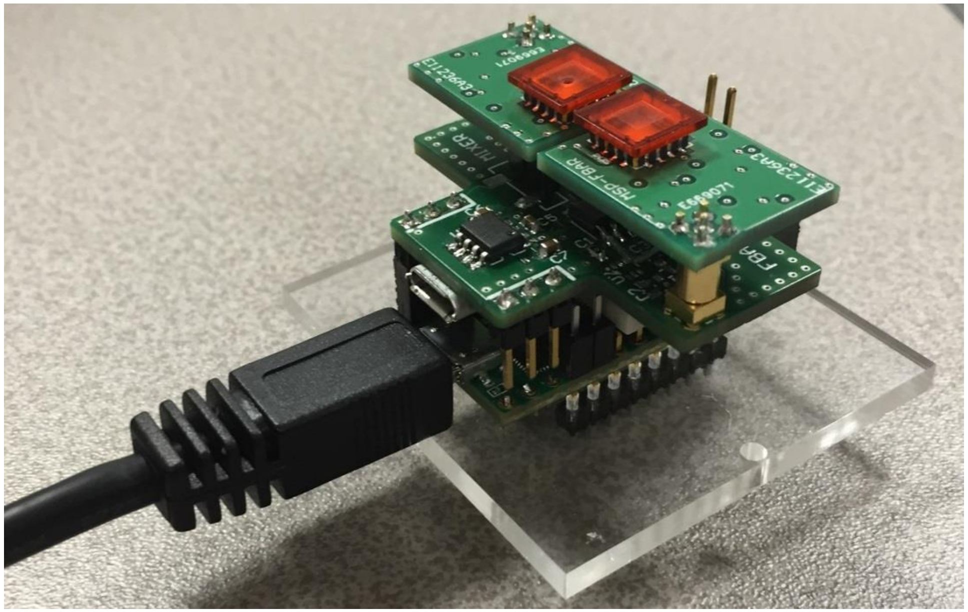
Particle Sensing Unit

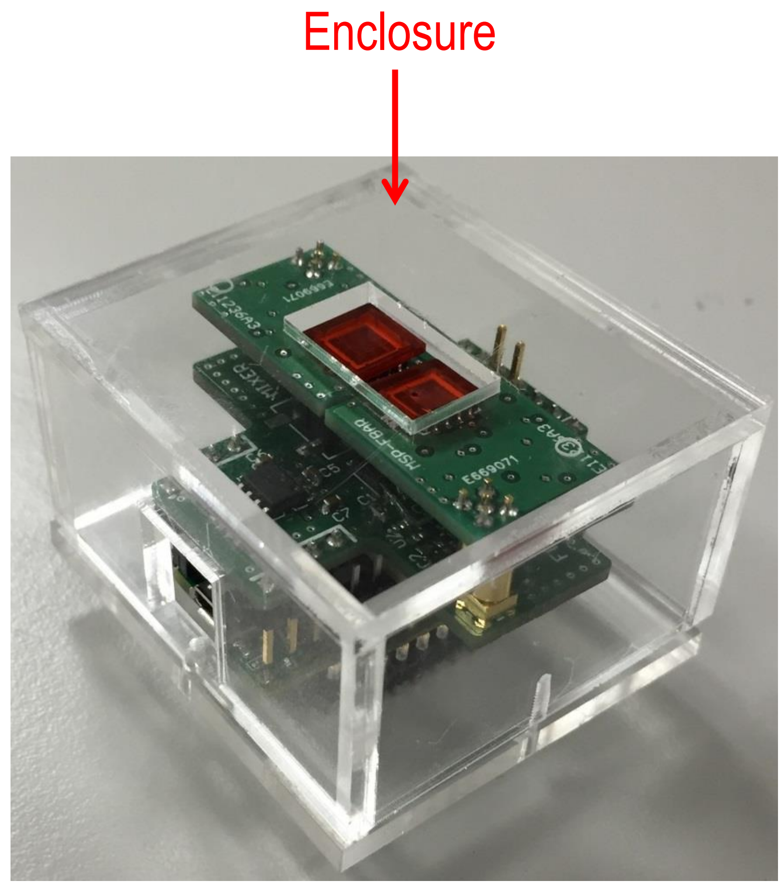
- Mass loading on the sensing device due to the total number of particles deposited causes a change in its resonant frequency.

- The differential frequency output of the mixer board is interfaced to a microcontroller.

Description of the system –

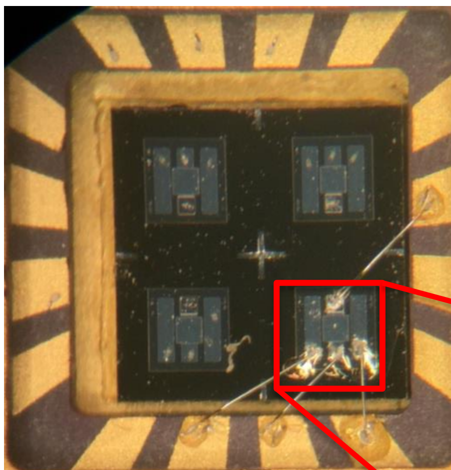
Particle Sensing Unit

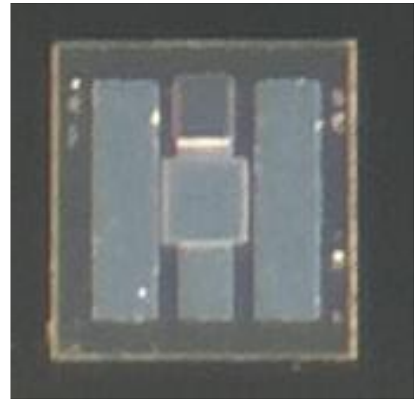


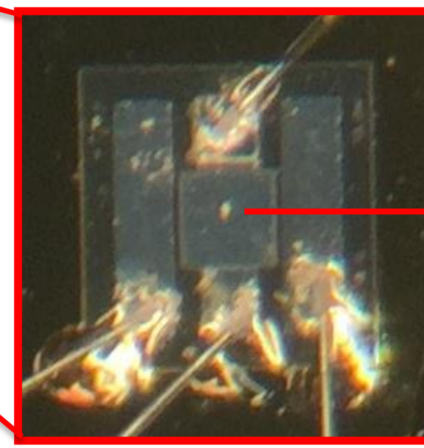


- Data is logged through a USB communication channel with LabVIEW software.

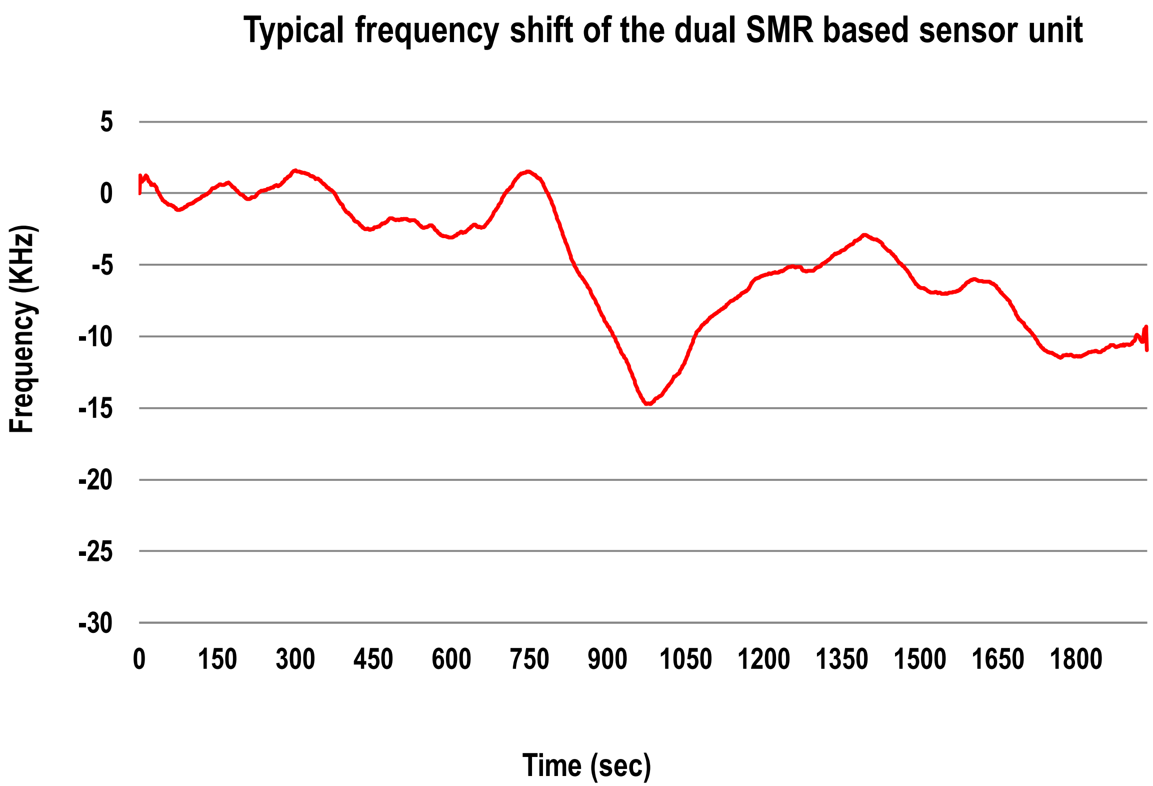
Preliminary Results – Particle detection







Preliminary Results – Particle detection



PM10 particles

Frequency Shift= 8 KHz

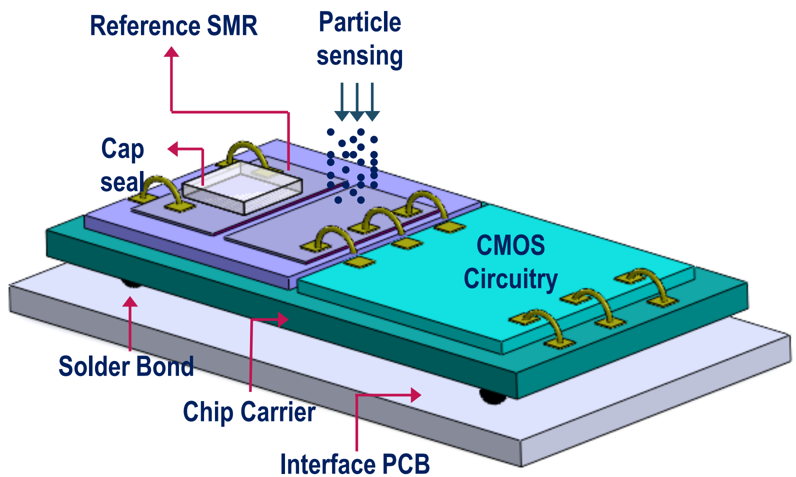
Sensitivity = 580 kHz/ng

Conclusions

- Application of bulk acoustic wave technology for particle sensing.
- Development of a portable particle sensing unit for particulate matter detection.
- Dual configuration in order to eliminate common mode variations.
- System capable of detecting fine particles with a sensitivity of 580 kHz/ng when detecting PM10.

Further work

- Miniaturisation of the system in CMOS technology as a smart low-cost particle air quality sensor.



Farah-Helúe Villa-López, Sanju Thomas, Marina Cole, Julian W. Gardner, "Finite Element Modelling of Particle Sensors based on Solidly Mounted Resonators", IEEE Sensors Conference 2014, Valencia, Spain, November 2014.

S. Thomas, **F.H. Villa-Lopez**, W.Ludurczak, M. Cole and J.W. Gardner, "Design, modelling and development of low cost high frequency piezoelectric particle sensor", EMR-S 2014 Spring Meeting, Lille, France, May 2014.

Thank you very much!