



# CATCH-U-DNA General Meeting

3<sup>rd</sup> December 2017, Tel Aviv, Israel

# WP1. Acoustic wave devices and measurement control unit

Objectives and current results

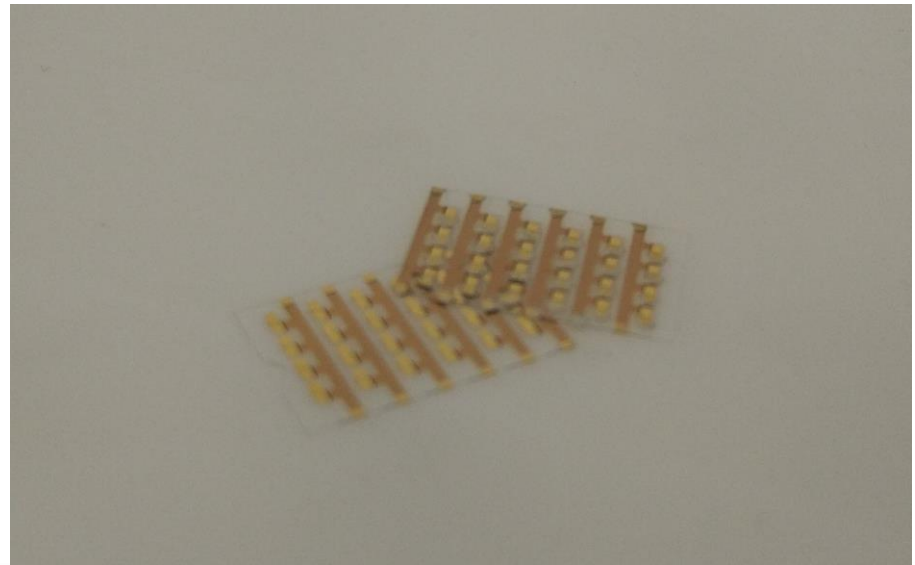
1. Objectives
2. Results
3. Next steps

# 1. Objectives

- Chip containing an array of TSBAR sensors

## Requirements

- Size < 6 cm<sup>2</sup>
- Cost < 2€ (mass production)
- Op. frequency between 150 MHz and 2GHz



# 1. Objectives



- Measurement system

## Requirements

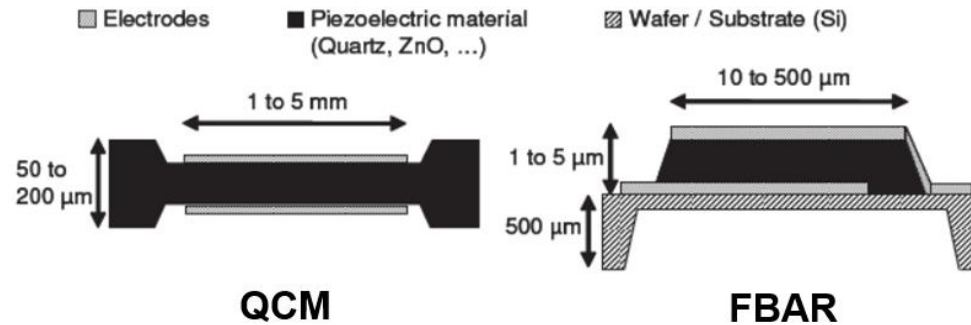
- High resolution
- Stability in the ppt range
- Real time



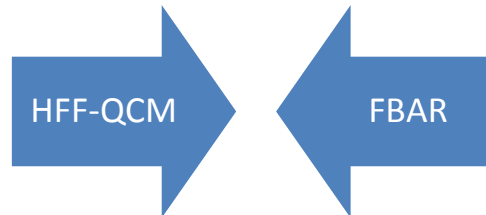
# 1. Objectives



# 1. Objectives



- Operating frequencies (100- 700 MHz)
- AT-cut quartz
- Integration capability (0.5 mm)
- High Q factor
- Low complexity
- Low cost

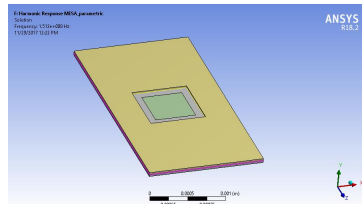


- Operating frequencies (1- 2 GHz)
- ZnO or AlN
- Integration capability (0.1 mm)
- CMOS standard
- Medium/High Complexity
- Low cost

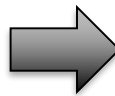
# 2. Results

**SENSOR  
DESIGN AND  
MODELING**  
**Task 1.1**  
**(M1-M15)**

## 3D FEM MODELING

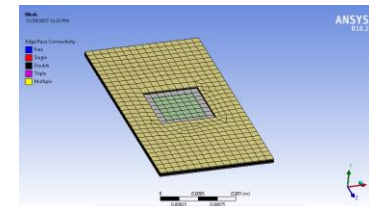
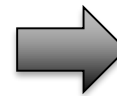


Geometry



Dielectric Matrix	$\begin{pmatrix} 39.21 & 0 & 0 \\ 0 & 39.82 & 0.86 \\ 0 & 0.86 & 40.42 \end{pmatrix} \cdot 10^{-12}$
Elastic Matrix	$\begin{pmatrix} 86.74 & -8.25 & 27.15 & -3.66 & 0 & 0 \\ -8.25 & 129.77 & -7.42 & 5.7 & 0 & 0 \\ 27.15 & -7.42 & 102.83 & 9.92 & 0 & 0 \\ -3.66 & 5.7 & 9.92 & 38.61 & 0 & 0 \\ 0 & 0 & 0 & 0 & 68.81 & 2.53 \\ 0 & 0 & 0 & 0 & 2.53 & 29.01 \end{pmatrix} \cdot 10^9$
Piezoelectric Matrix	$\begin{pmatrix} 0.171 & -0.152 & -0.0187 & 0 & 0 \\ 0 & 0 & 0 & 0.108 & -0.095 \\ 0 & 0 & 0 & -0.0761 & 0.067 \end{pmatrix}$

Material



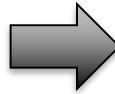
Meshing

$$\frac{\partial u}{\partial n} \Big|_{\Gamma_2} = g$$

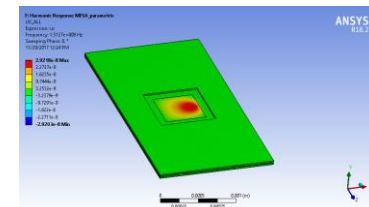
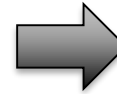
$$\Omega$$

$$u|_{\Gamma_1} = u_0$$

Boundary  
Conditions



Analysis



PostProc



## 2. Results

SENSOR  
DESIGN AND  
MODELING  
**Task 1.1**  
(M1-M15)

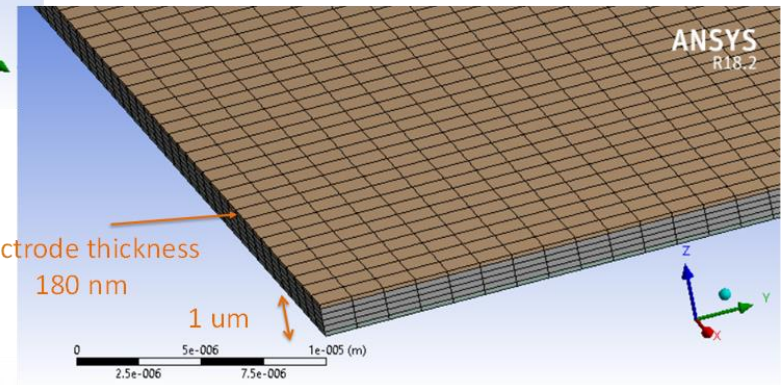
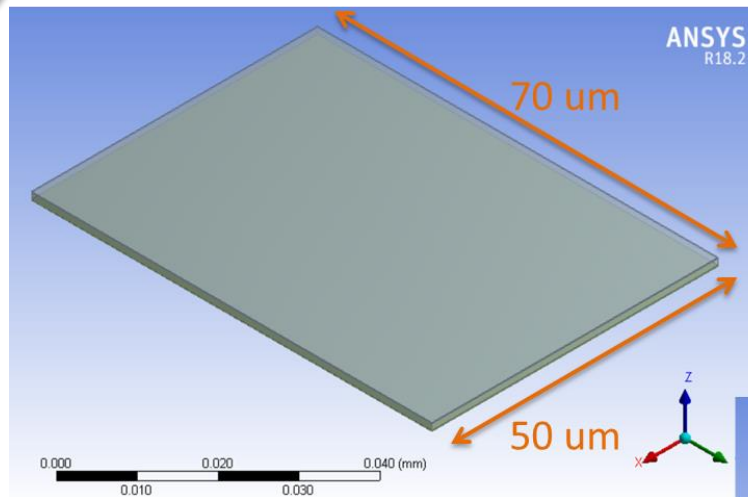
### 3D FEM MODELING



## 2. Results

SENSOR  
DESIGN AND  
MODELING  
**Task 1.1**  
(M1-M15)

### FBAR SENSOR MODELING

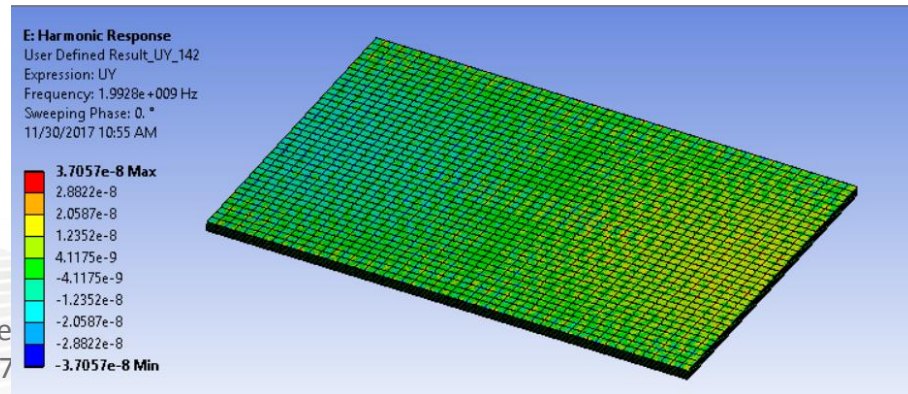
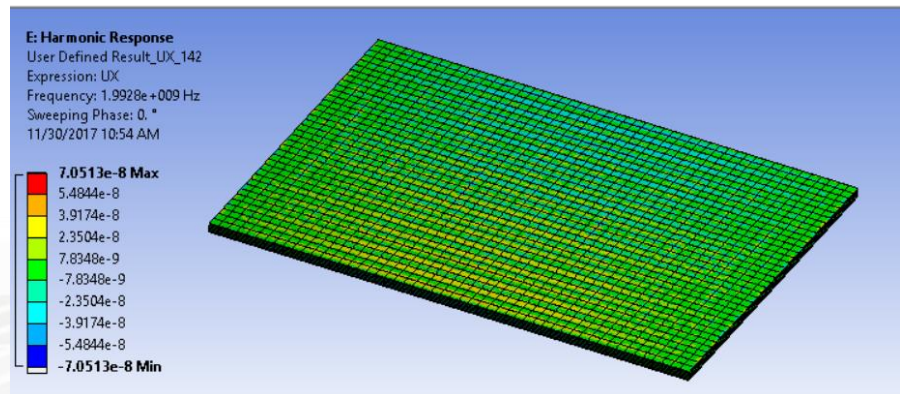
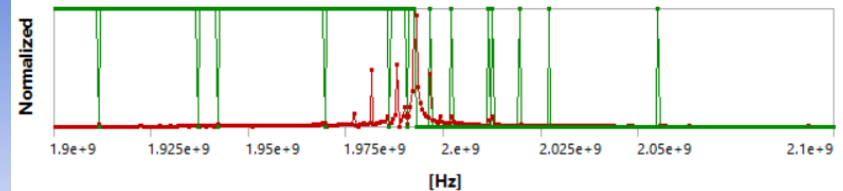
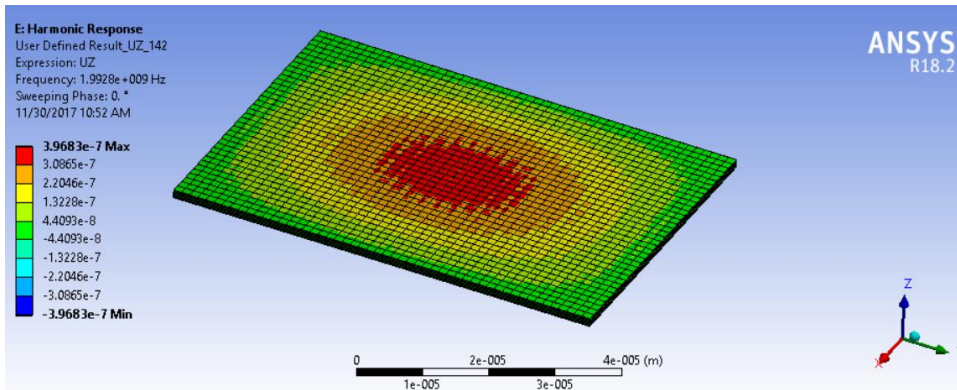


# 2. Results

SENSOR  
DESIGN AND  
MODELING  
Task 1.1  
(M1-M15)

## FBAR SENSOR MODELING

AlN substrate – Pt electrodes **FBAR**



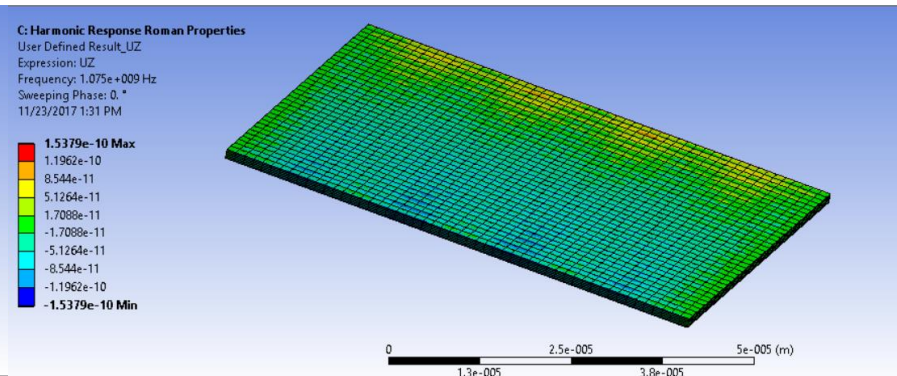
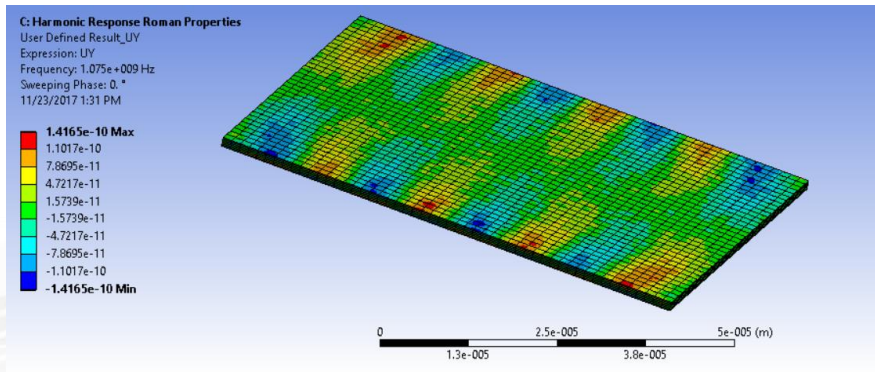
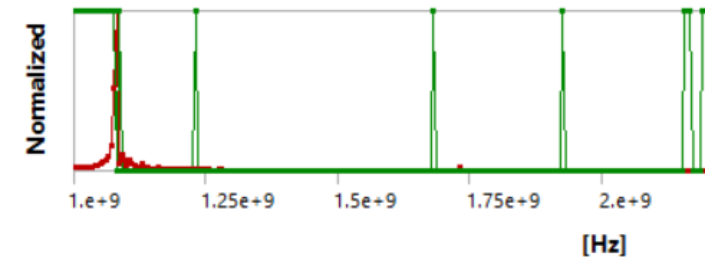
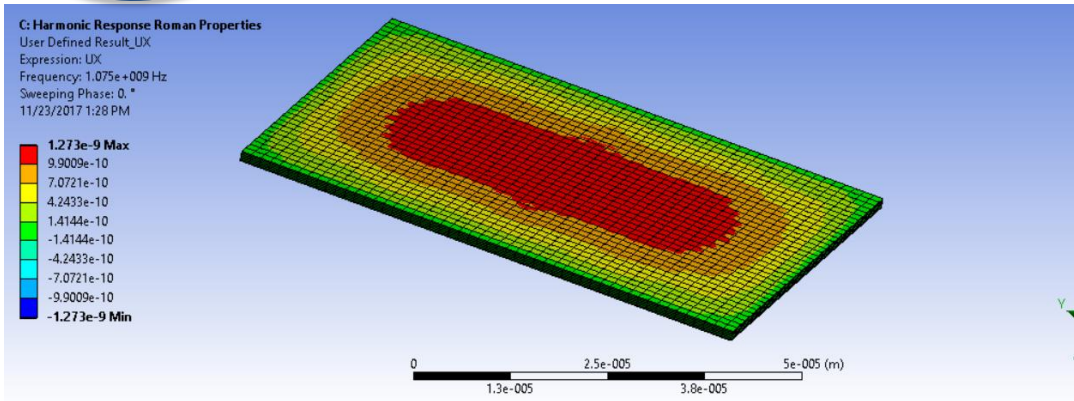


# 2. Results

SENSOR  
DESIGN AND  
MODELING  
**Task 1.1**  
(M1-M15)

## FBAR SENSOR MODELING

AlN substrate – Pt electrodes **S-FBAR**



# 2. Results

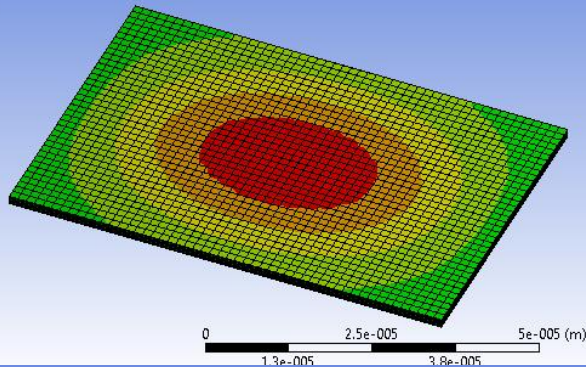
SENSOR  
DESIGN AND  
MODELING  
Task 1.1  
(M1-M15)

## FBAR SENSOR MODELING

ZnO substrate – Pt electrodes **S-FBAR**

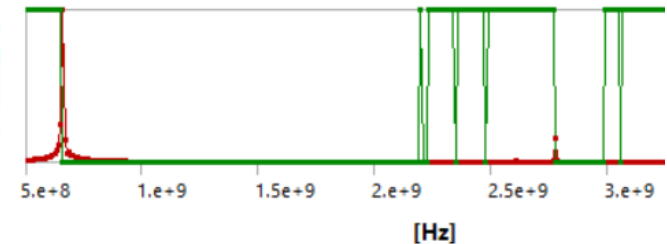
D: Harmonic Response ZnO-SFBAR  
User Defined Result\_UY  
Expression: UY  
Frequency: 6.5625e+008 Hz  
Sweeping Phase: 0. °  
11/30/2017 12:01 PM

9.5396e-9 Max  
7.4197e-9  
5.2998e-9  
3.1799e-9  
1.06e-9  
-1.06e-9  
-3.1799e-9  
-5.2998e-9  
-7.4197e-9  
-9.5396e-9 Min



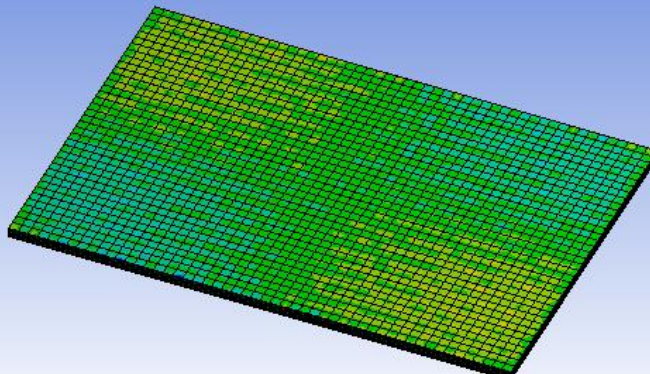
ANSYS  
R18.2

Normalized



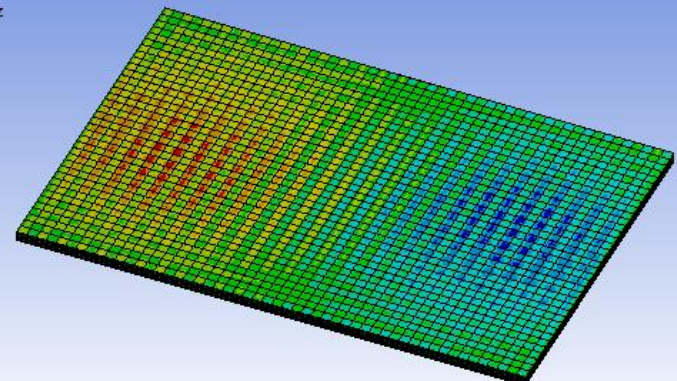
D: Harmonic Response ZnO-SFBAR  
User Defined Result\_UX  
Expression: UX  
Frequency: 6.5625e+008 Hz  
Sweeping Phase: 0. °  
11/30/2017 12:02 PM

2.1727e-10 Max  
1.6899e-10  
1.2071e-10  
7.2424e-11  
2.4141e-11  
-2.4141e-11  
-7.2424e-11  
-1.2071e-10  
-1.6899e-10  
-2.1727e-10 Min



D: Harmonic Response ZnO-SFBAR  
User Defined Result\_UZ  
Expression: UZ  
Frequency: 6.5625e+008 Hz  
Sweeping Phase: 0. °  
11/30/2017 12:02 PM

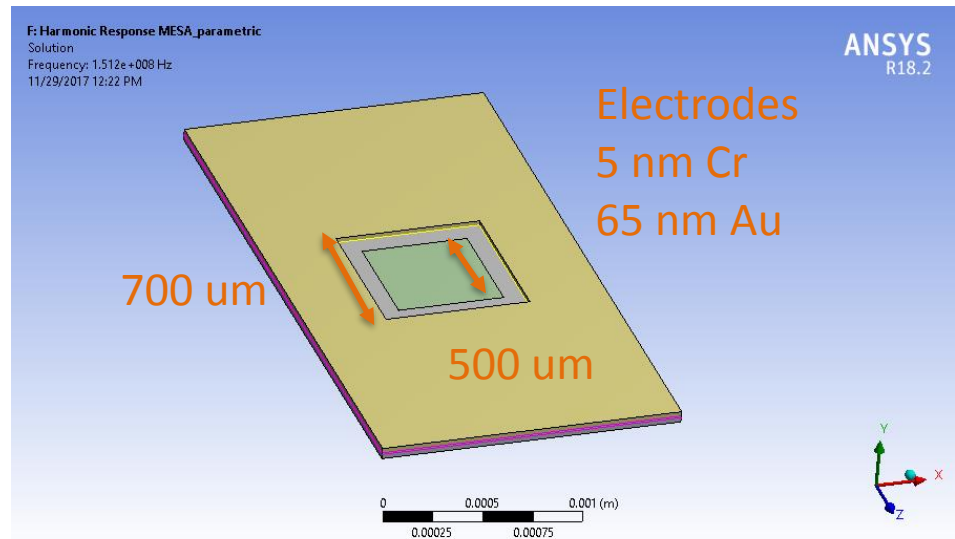
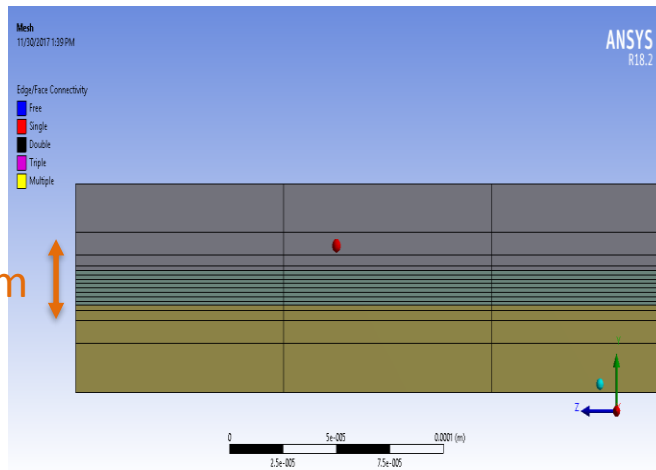
3.2284e-10 Max  
2.511e-10  
1.7936e-10  
1.0761e-10  
3.5871e-11  
-3.5871e-11  
-1.0761e-10  
-1.7936e-10  
-2.511e-10  
-3.2284e-10 Min



# 2. Results

SENSOR  
DESIGN AND  
MODELING  
**Task 1.1**  
(M1-M15)

## HFFQCM SENSOR MODELING

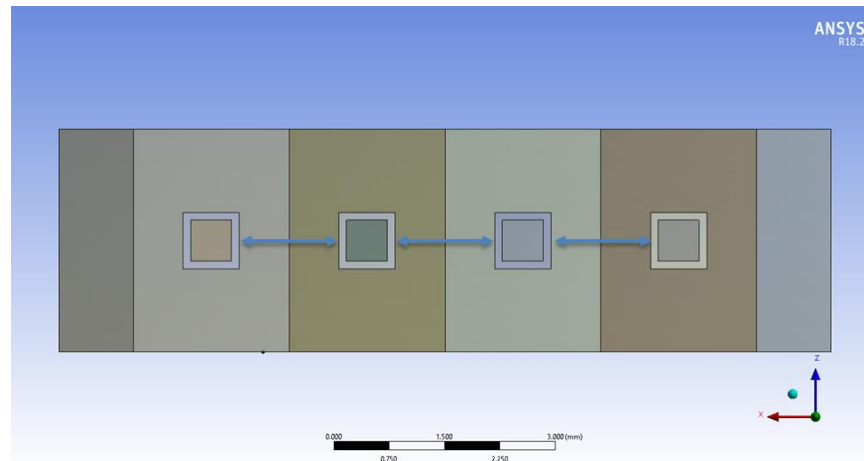


## 2. Results

SENSOR  
DESIGN AND  
MODELING  
**Task 1.1**  
(M1-M15)

### HFFQCM SENSOR MODELING

Array parametric study: **Spacing**



	DP0	DP1	DP2	DP3	DP4
Spacing (mm)	1.408	1.584	1.76	1.936	2.112

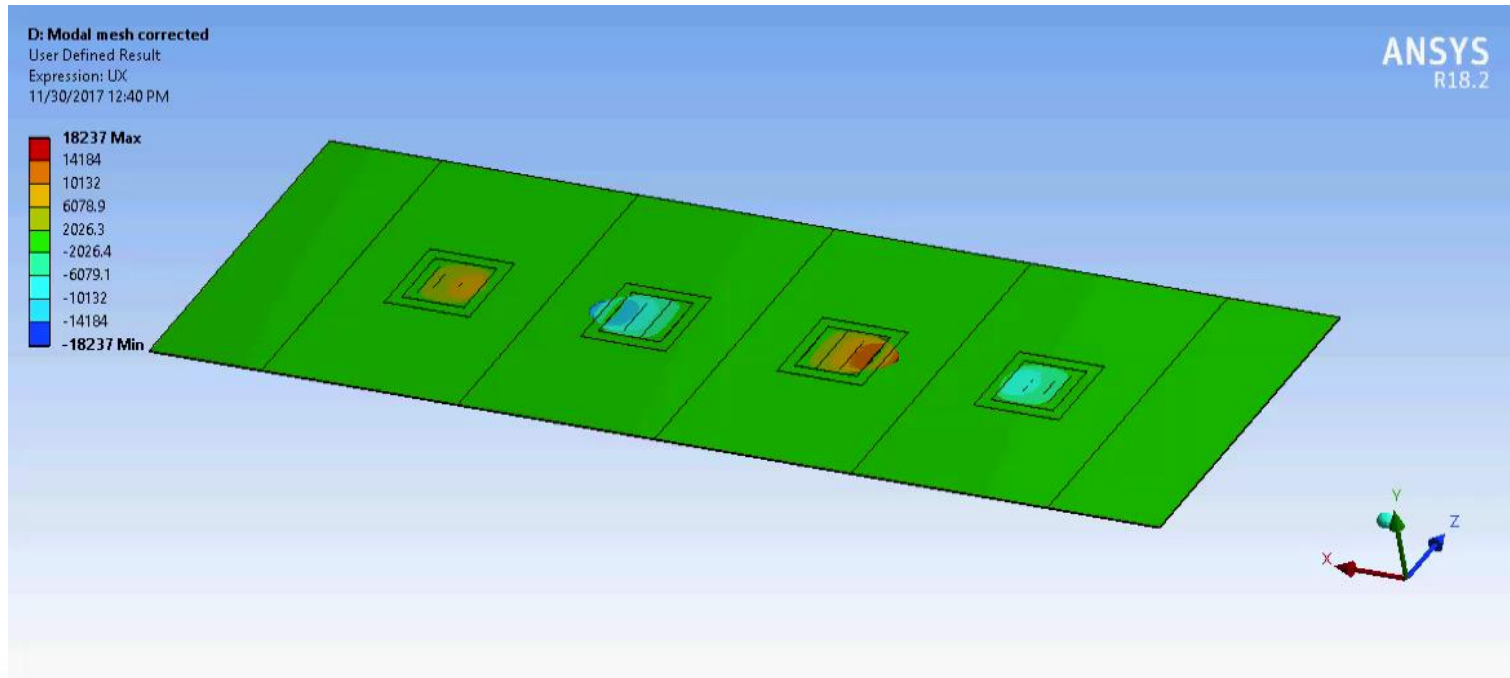


# 2. Results

SENSOR  
DESIGN AND  
MODELING  
Task 1.1  
(M1-M15)

## HFFQCM SENSOR MODELING

### Modal Analysis



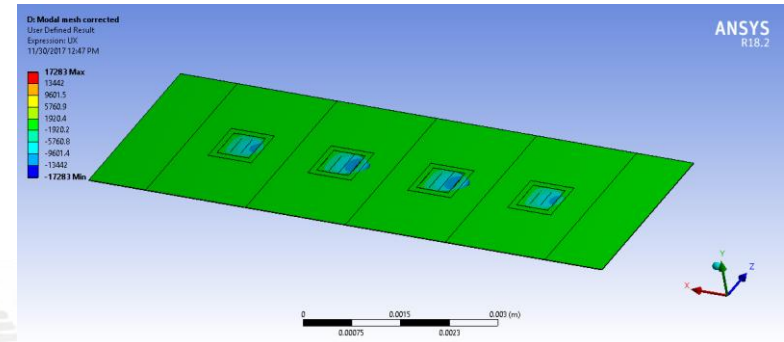
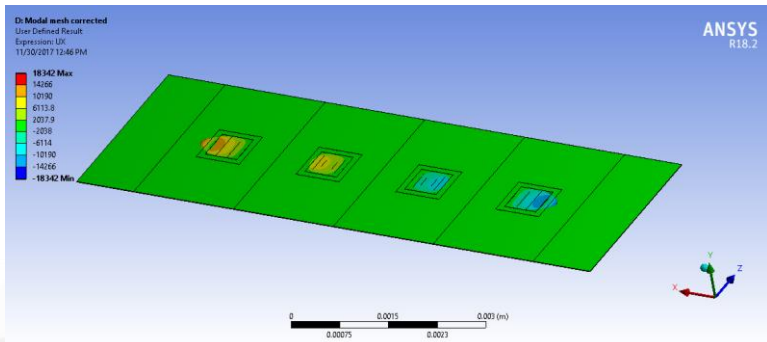
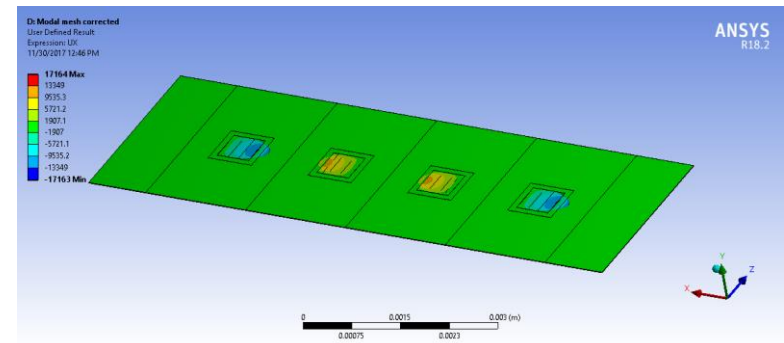
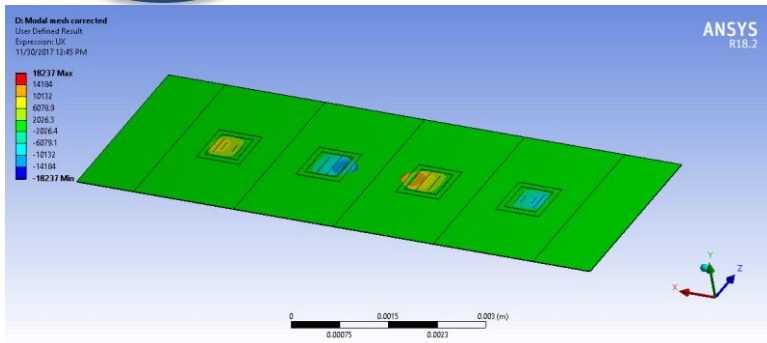


# 2. Results

SENSOR  
DESIGN AND  
MODELING  
Task 1.1  
(M1-M15)

## HFFQCM SENSOR MODELING

### Modal Analysis

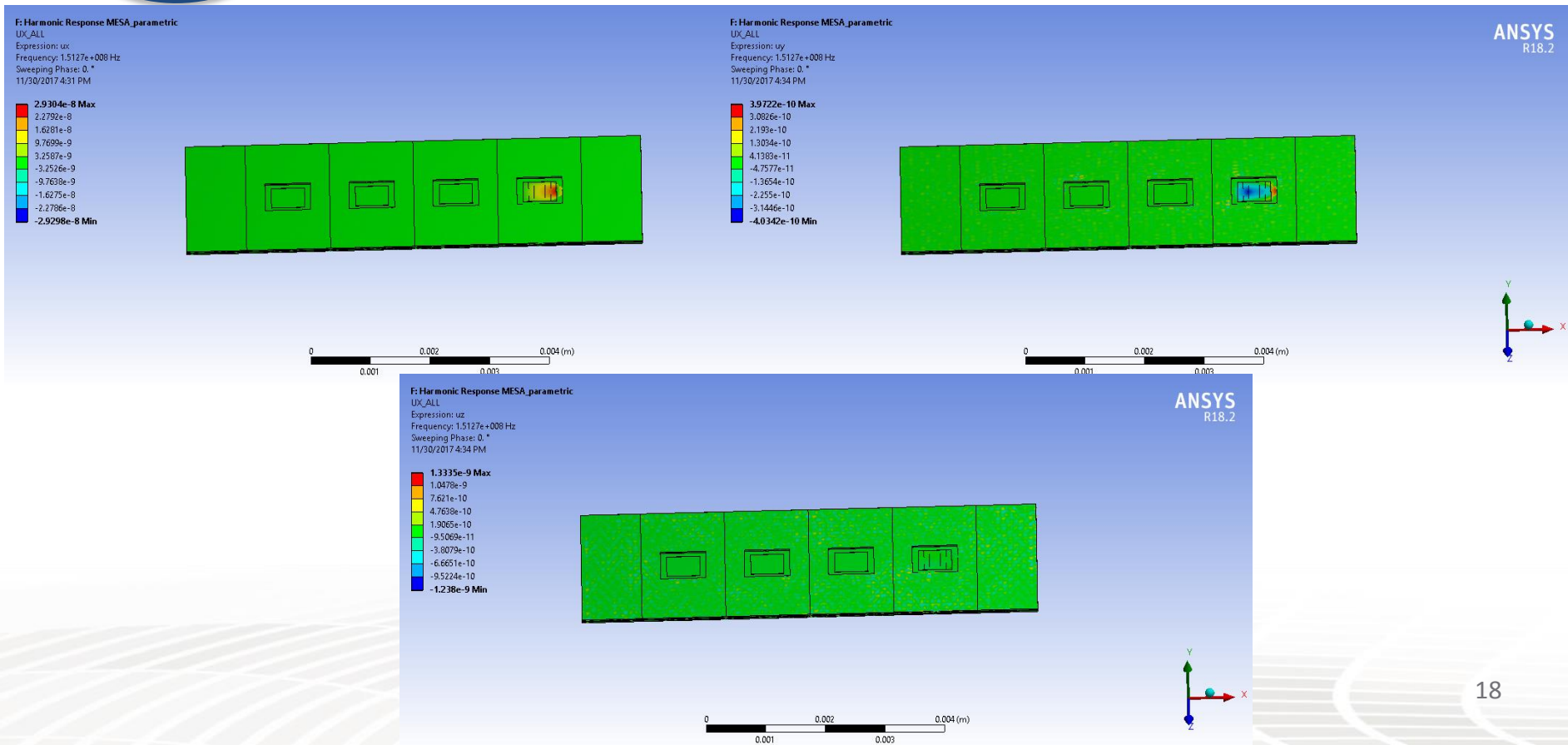


# 2. Results

SENSOR  
DESIGN AND  
MODELING  
Task 1.1  
(M1-M15)

## HFFQCM SENSOR MODELING

### Harmonic Analysis

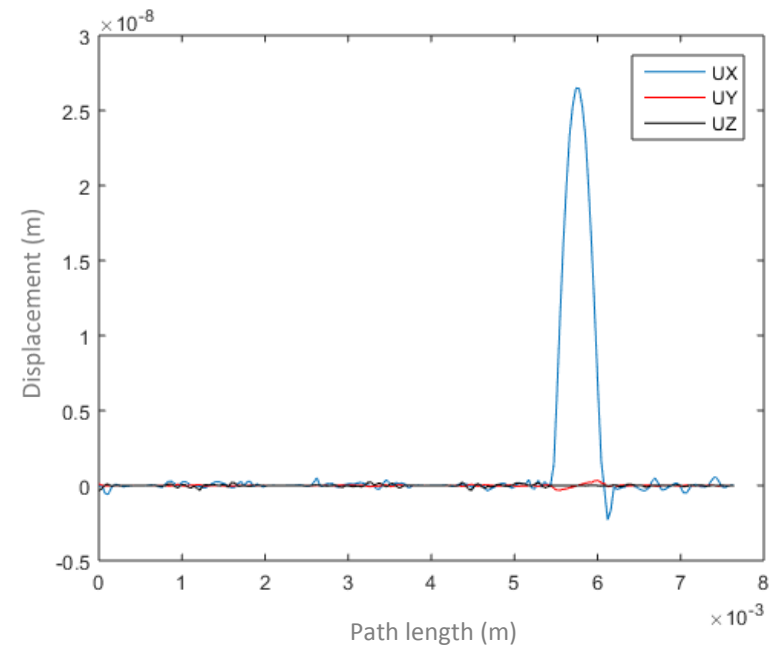
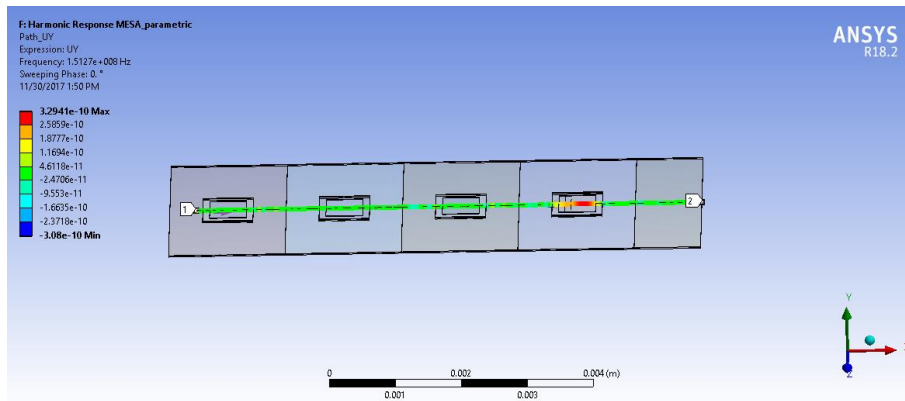


# 2. Results

SENSOR  
DESIGN AND  
MODELING  
**Task 1.1**  
**(M1-M15)**

## HFFQCM SENSOR MODELING

### Harmonic Analysis

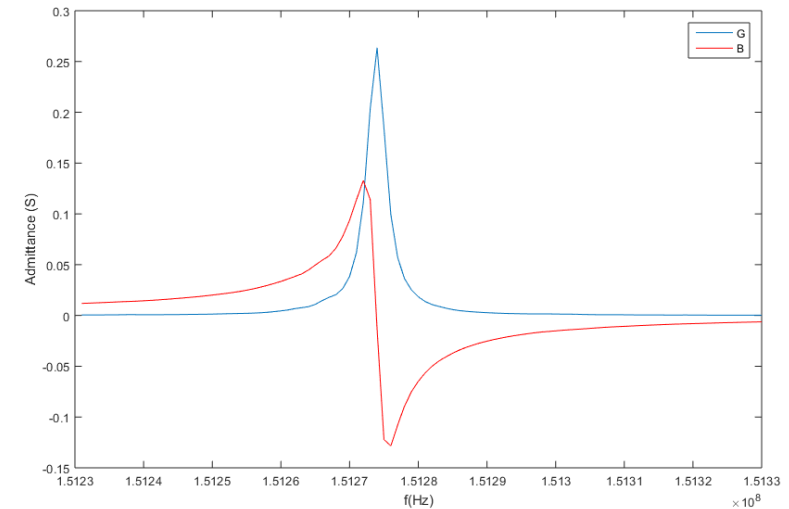
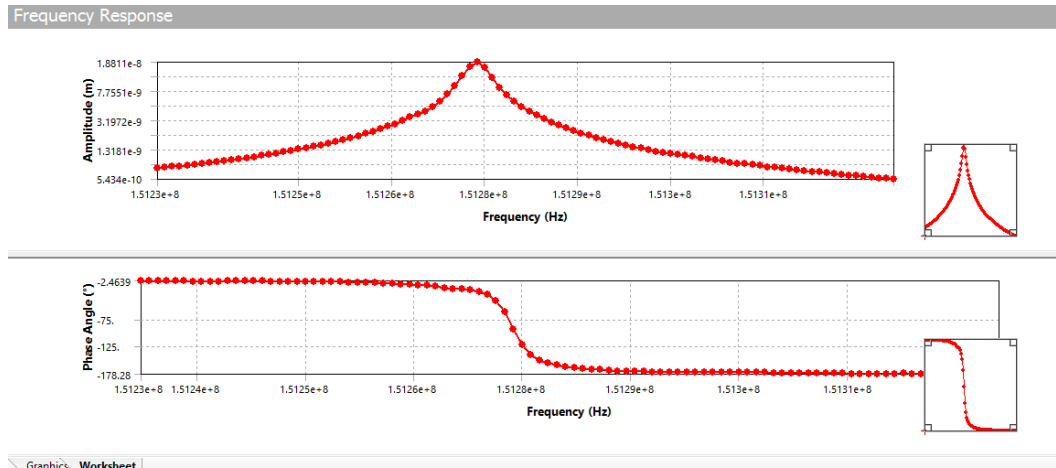


# 2. Results

SENSOR  
DESIGN AND  
MODELING  
Task 1.1  
(M1-M15)

## HFFQCM SENSOR MODELING

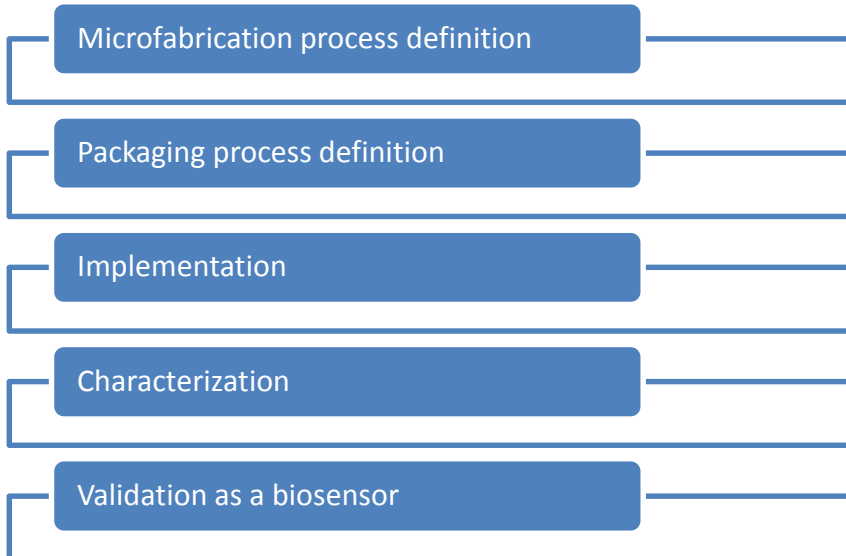
### Harmonic Analysis



## 2. Results



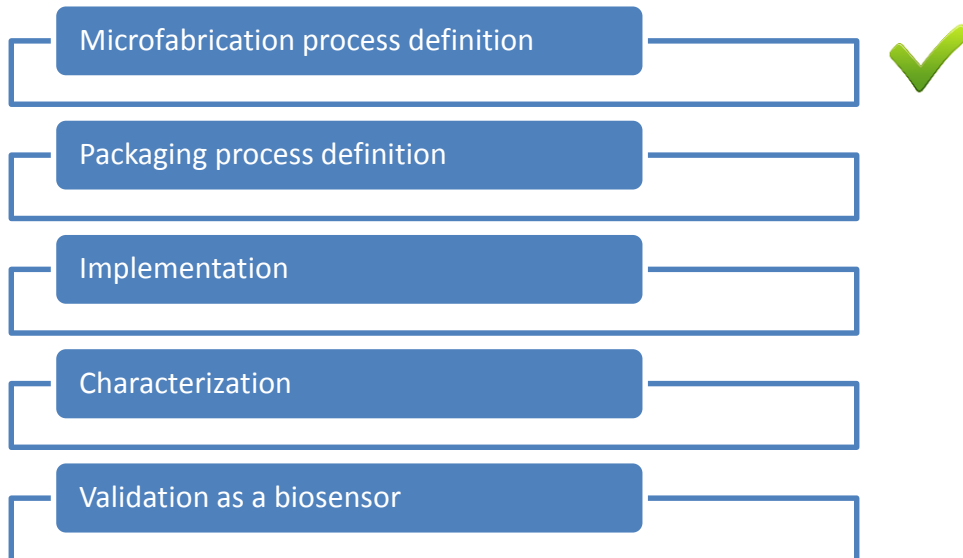
### SENSOR FABRICATION PROCEDURE



## 2. Results

**SENSOR  
FABRICATION**  
**Task 1.2**  
**(M4-M18)**

### SENSOR FABRICATION PROCEDURE



- Definition of the inverted mesa manufacturing process (wet etching single-side)
- Photomask tooling draft design
- Electrode Plating Mask tooling draft design

## 2. Results

**SENSOR  
FABRICATION**  
**Task 1.2**  
**(M4-M18)**

### SENSOR FABRICATION PROCEDURE

Microfabrication process definition

Packaging process definition

Implementation

Characterization

Validation as a biosensor



- Electric interface design

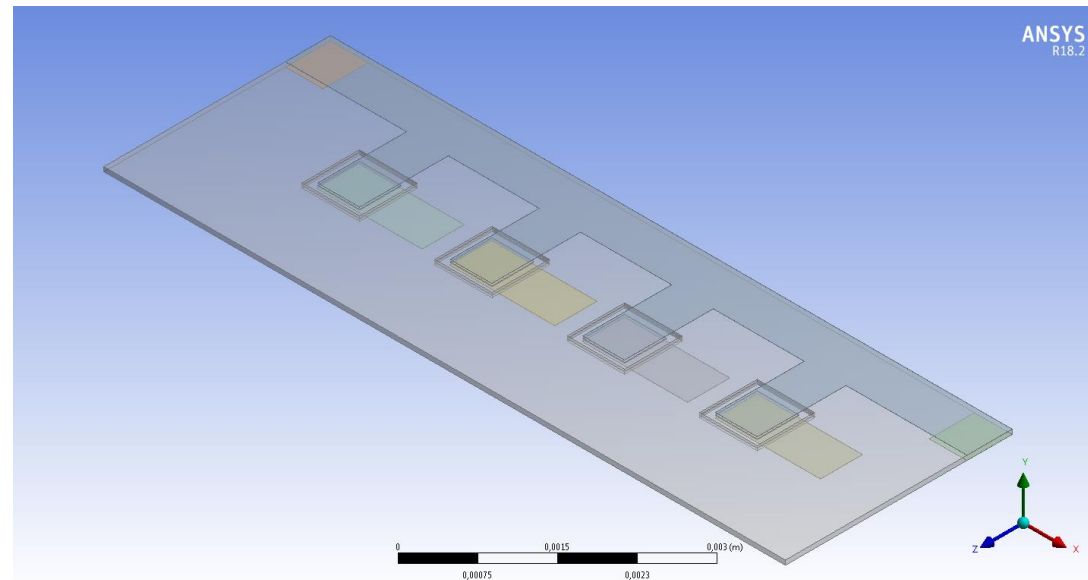


# 2. Results

SENSOR  
FABRICATION  
Task 1.2  
(M4-M18)

## FIRST PROTOTYPE

- Numerical Model Calibration (Damping)
- Manufacturing process validation
- uFluidic cell proof of concept
- Preliminary testing with bio-samples





# 3. Next Steps



## ONGOING WORK

- Multiphysics postprocessing to estimate insertion losses ( $S_{21}$ ) in sensor arrays
- Development of a more detailed S-FBAR model
- S-FBAR array design and model
- HFF-QCM array design optimization using parametric design techniques
- S-FBAR array design optimization using parametric design techniques
- S-FBAR vs. HFF-QCM Comparative analysis in terms of  $S$  and  $Q$  and interference

# 3. Next Steps



## ONGOING WORK

- Implementation of the 4-sensor HFF-QCM array first prototype
- Development of the prototype packaging
- HFF-QCM prototype characterization

# 3. Next Steps



MEASURING  
TECHNIQUE  
**Task 1.3**  
**(M1-M12)**

## ONGOING WORK

- Development of the electrical/mechanical interface for HFF-QCM prototype
- Increasing frequency range (image frequency)
- Mixed (Tracking- Fixed frequency) characterization algorithm