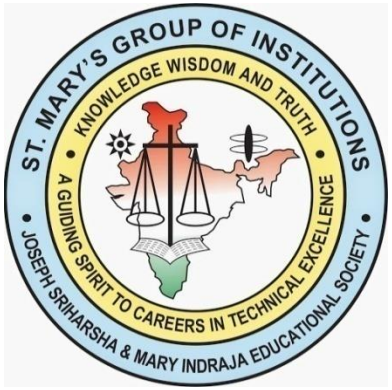
COMSOL CONFERENCE 2015 PUNE

Design of FIDT for 3D Analysis of MEMS Based Gas Sensor Using SAW Technology



Department of Control Systems,

Electrical & Electronics Engineering,

St. Mary's Group of Institutions-Hyderabad,

Jawaharlal Nehru Technological University-Hyderabad, Telangana.

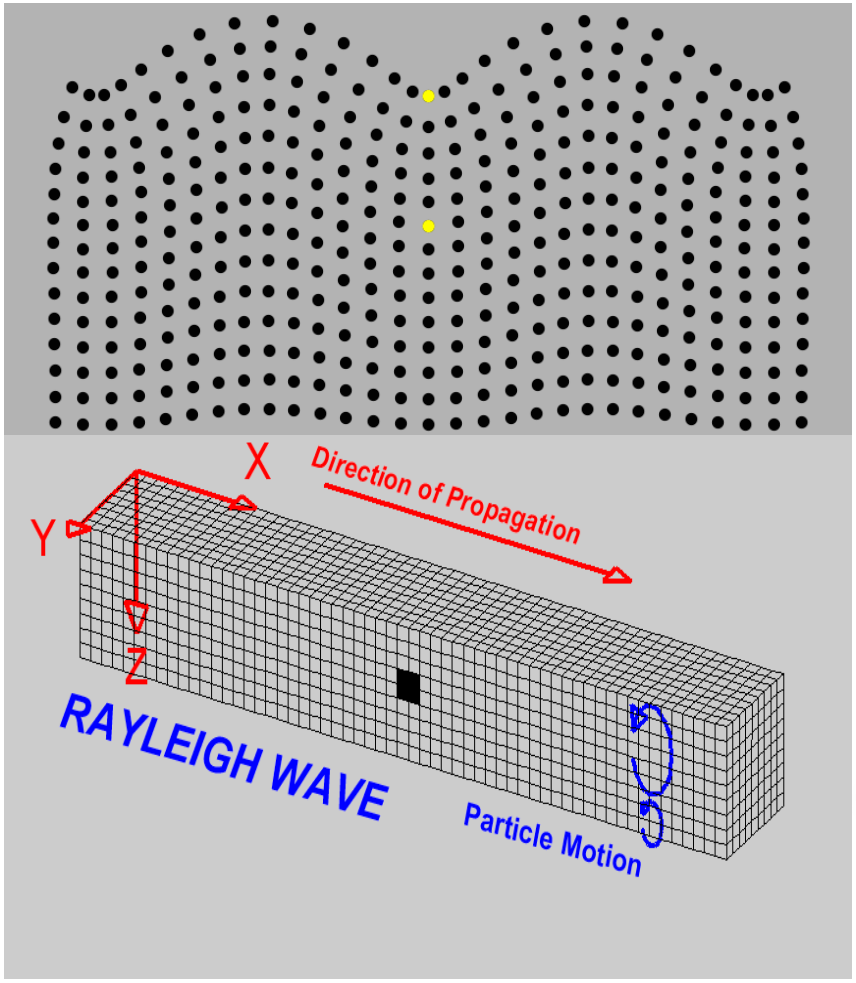
Excerpt from the Proceedings of the COMSOL Conference 2015 PUNE.

CONTENTS

1. INTRODUCTION

SAW

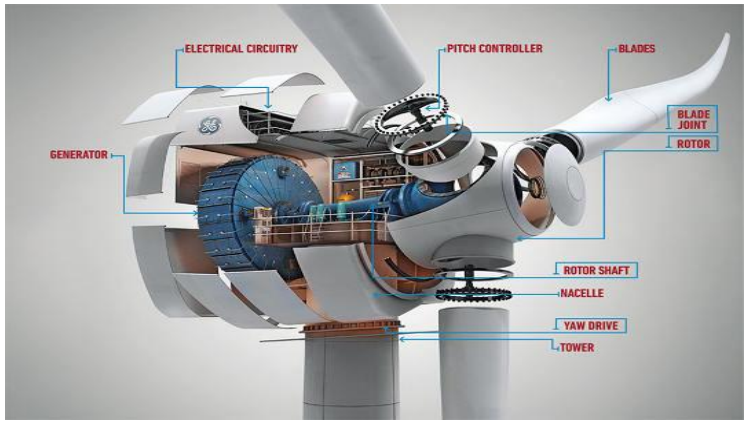
Surface Acoustic Wave



2. APPLICATIONS

Industry: Passive wireless measurement of Temperature, Pressure, Strain, Vibrations.

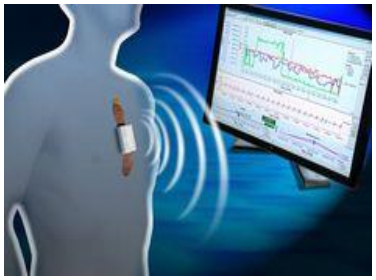
Energy: Switch gear temperature monitoring, Wind turbine generator monitoring, Bearing Temperature Control in Electrical equipments.

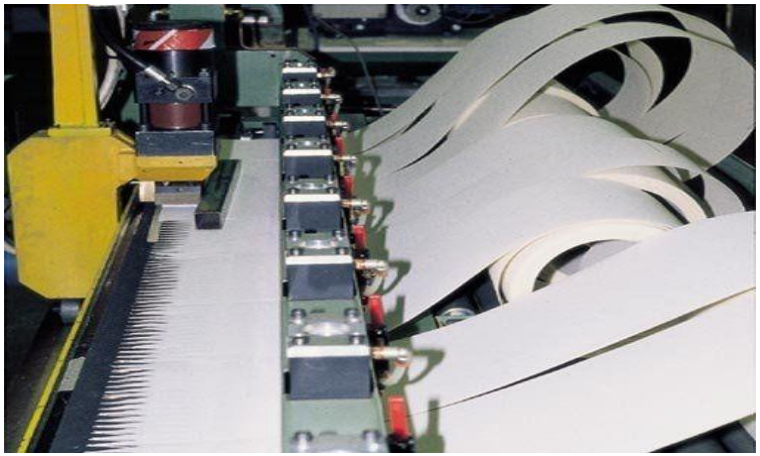


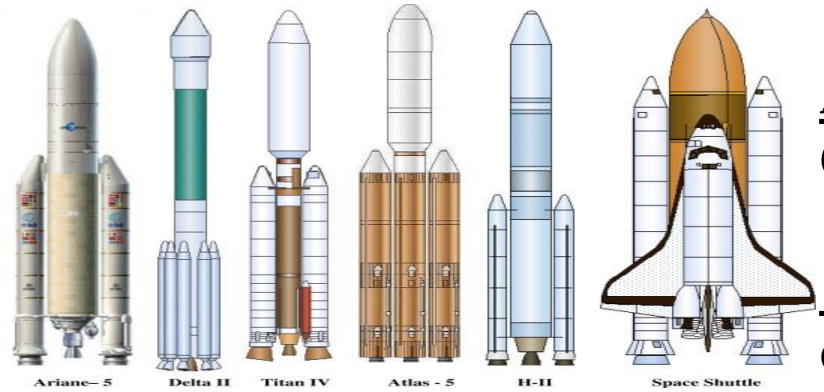
Power Plant: Detection of dangerous gases like sulphur dioxide near chimney/ stack.

Communication: Mobile phones, as filters, oscillators, resonators, RFID sensors etc.

Research: Microfluidics, micropumps, micromixers, micro actuators, LOC, Inkjet Droplet based applications.







Chemical Plants: Detection of gases like CO2, CO, SO2, O2, O3, H2, Ar, N2, NH3 &volatile organic gases like carbon tetrachloride & trichloroethylene, etc.

Home Appliances: Cookware wireless monitoring, Wireless food probes, Wireless temperature control on rotating parts.

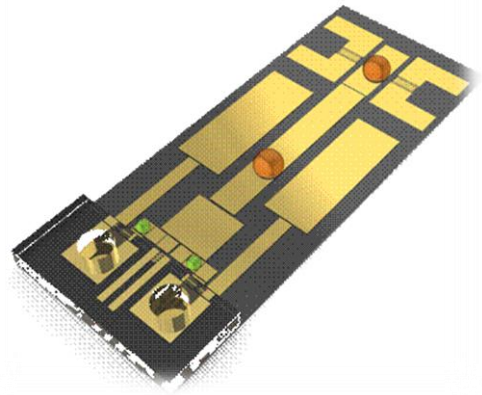
Biomedical: Patient monitoring / diagnostic sensors for lung cancer, biomarkers, MRI etc.

Laboratory: pH Levels, Biochemical sensors.

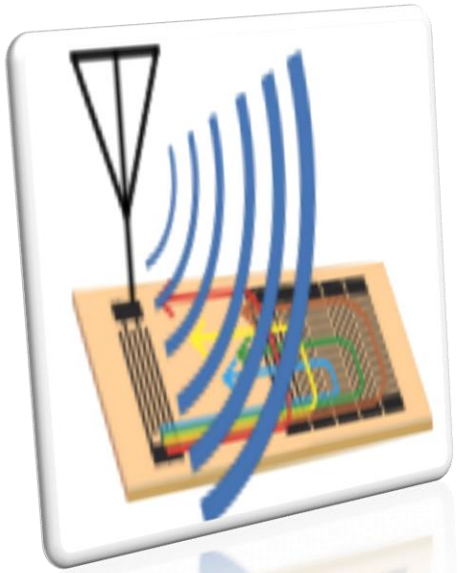
Automation: Production line monitoring, Conveyors tunnel oven, Roll temperature control.

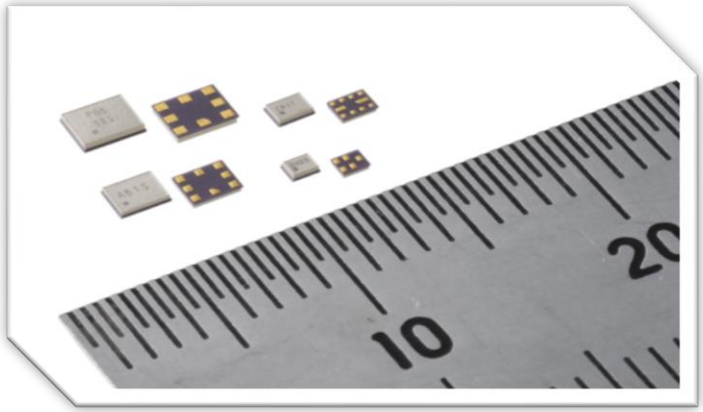
Automobile: Humidity, wing deflection controlling, IVHM in Aerospace / Space vehicles.

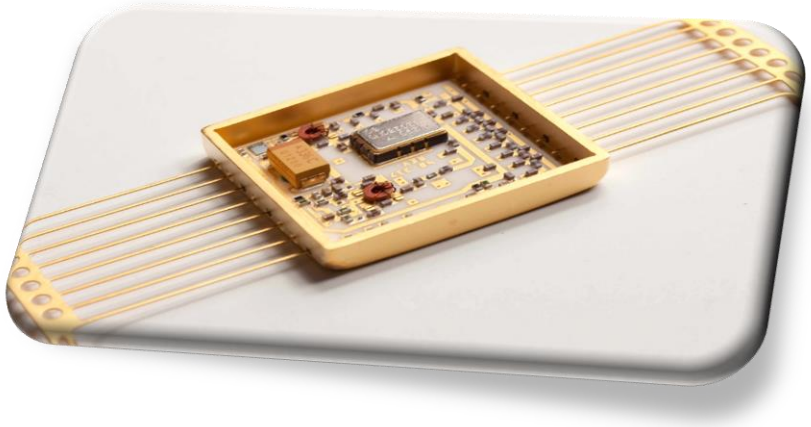
3. SIGNIFICANCE



- Passive,
- Wireless,
- Reliability,
- Portability,
- Ruggedness,
- Light Weight,
- Miniature size,
- High sensitivity,
- Faster response,
- Simplistic design,
- Mass- production,
- Variety of measurable phenomena.



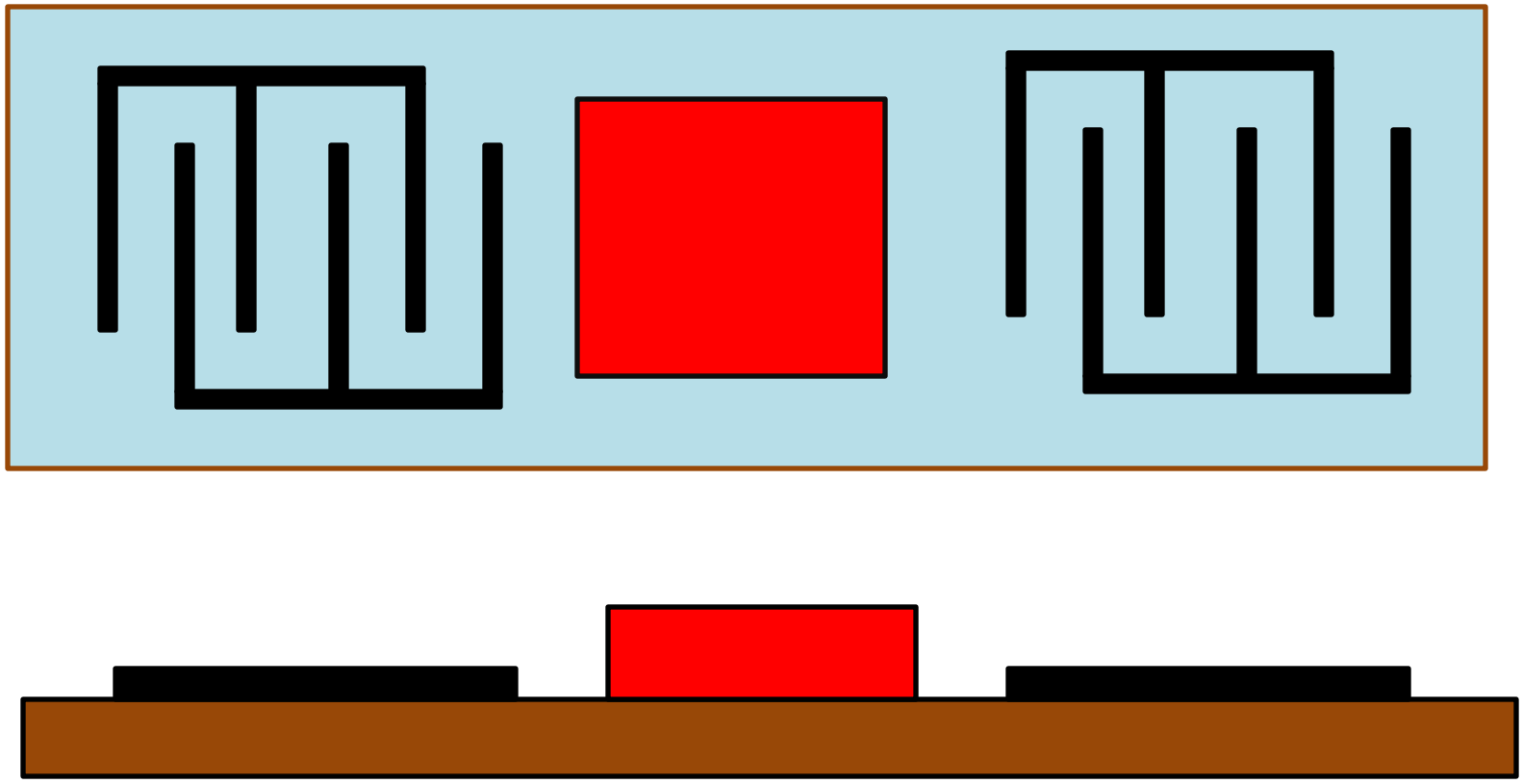


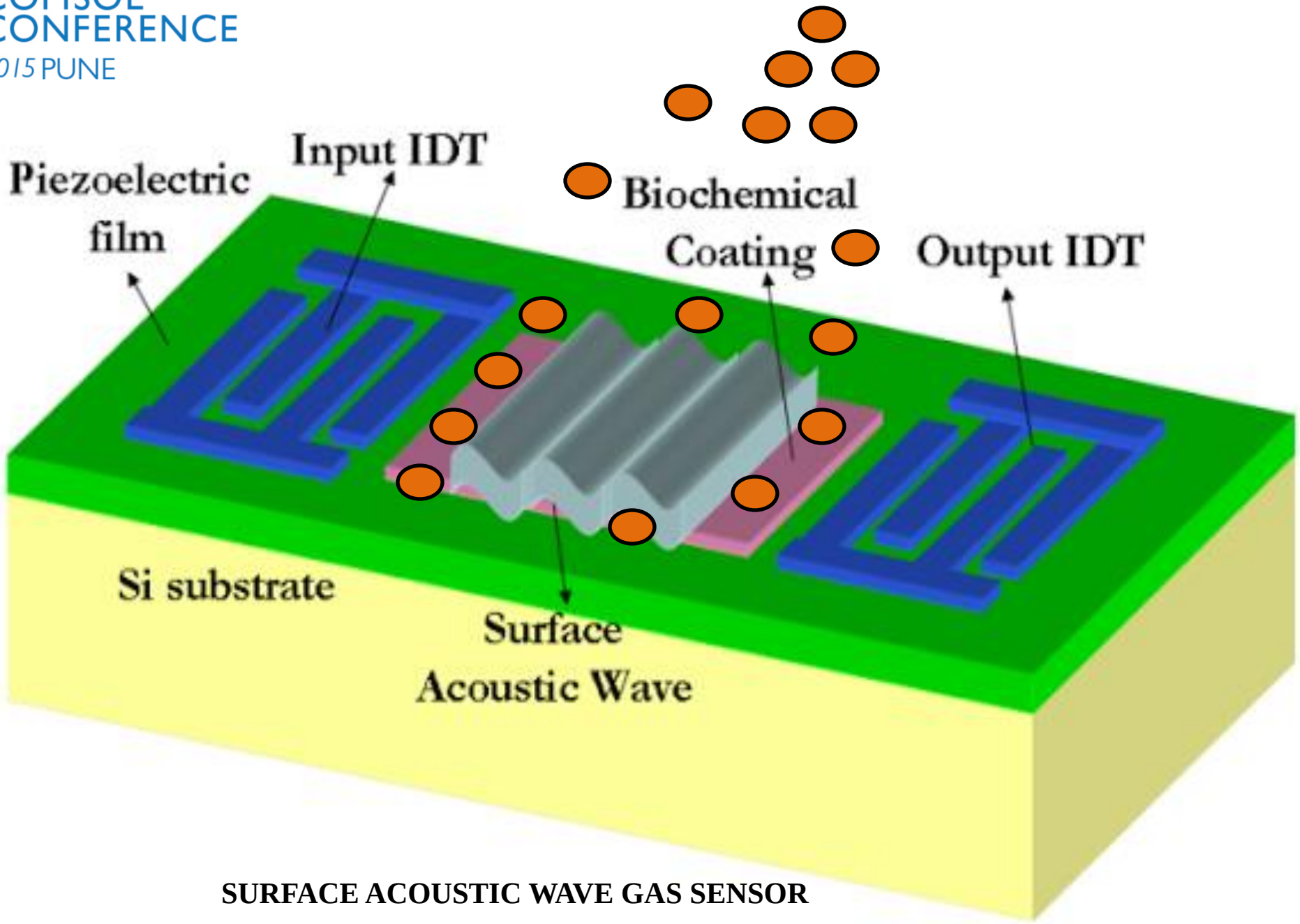


4. THEORY OF OPERATION

Components:

1. IDT, 2. Sensitive film, 3. Piezoelectric material

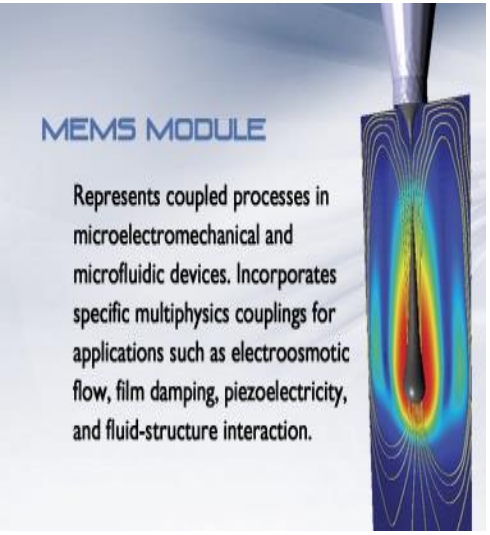


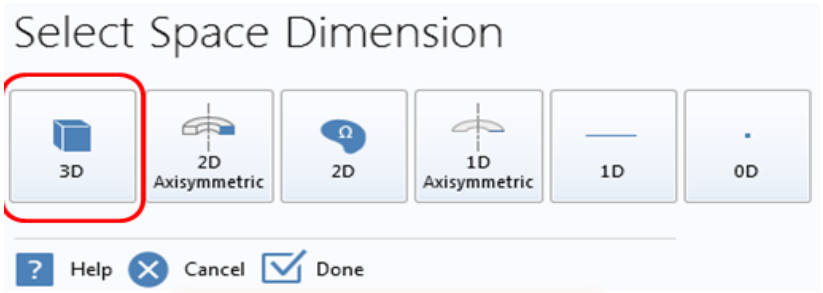


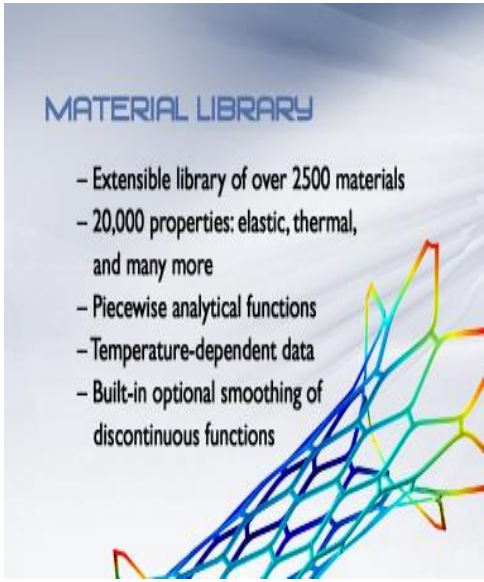
SURFACE ACOUSTIC WAVE GAS SENSOR

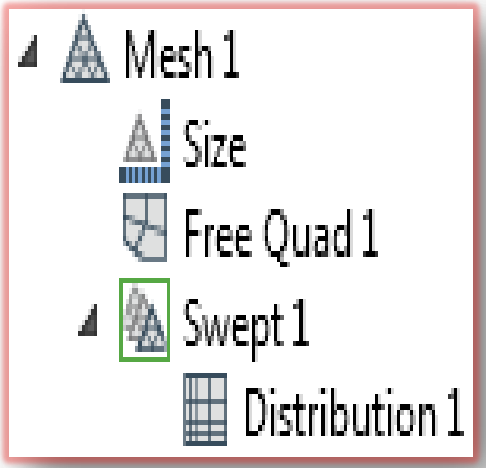
Excerpt from the Proceedings of the COMSOL Conference 2015 PUNE.

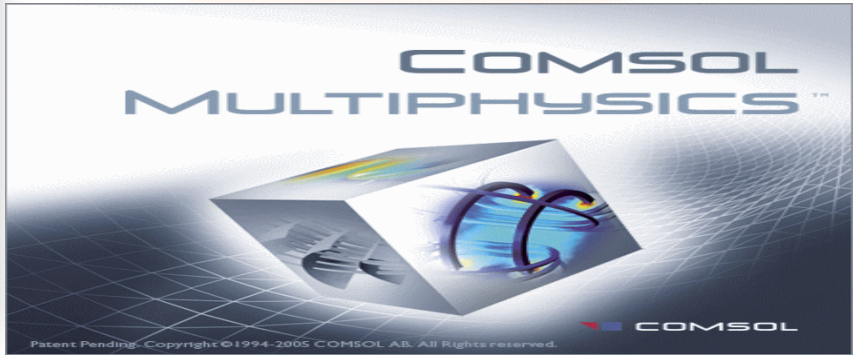
5. COMSOL Multiphysics

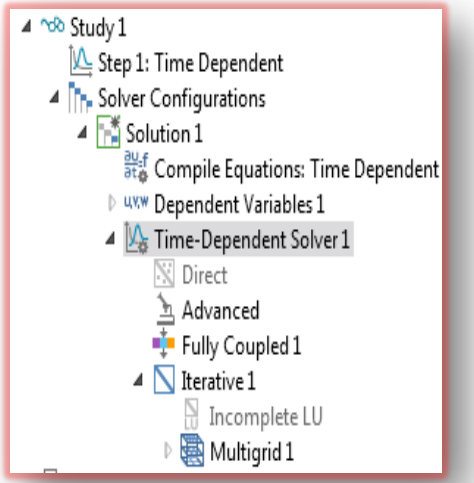




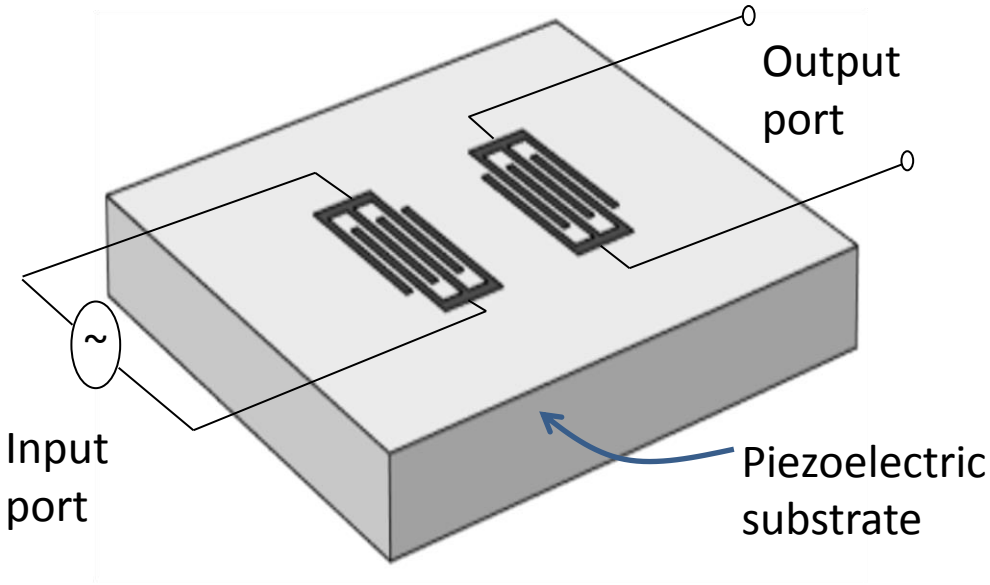




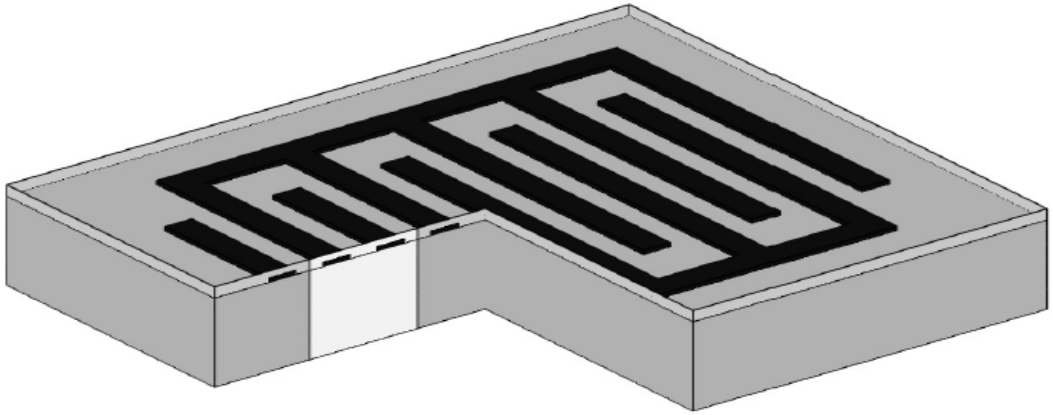




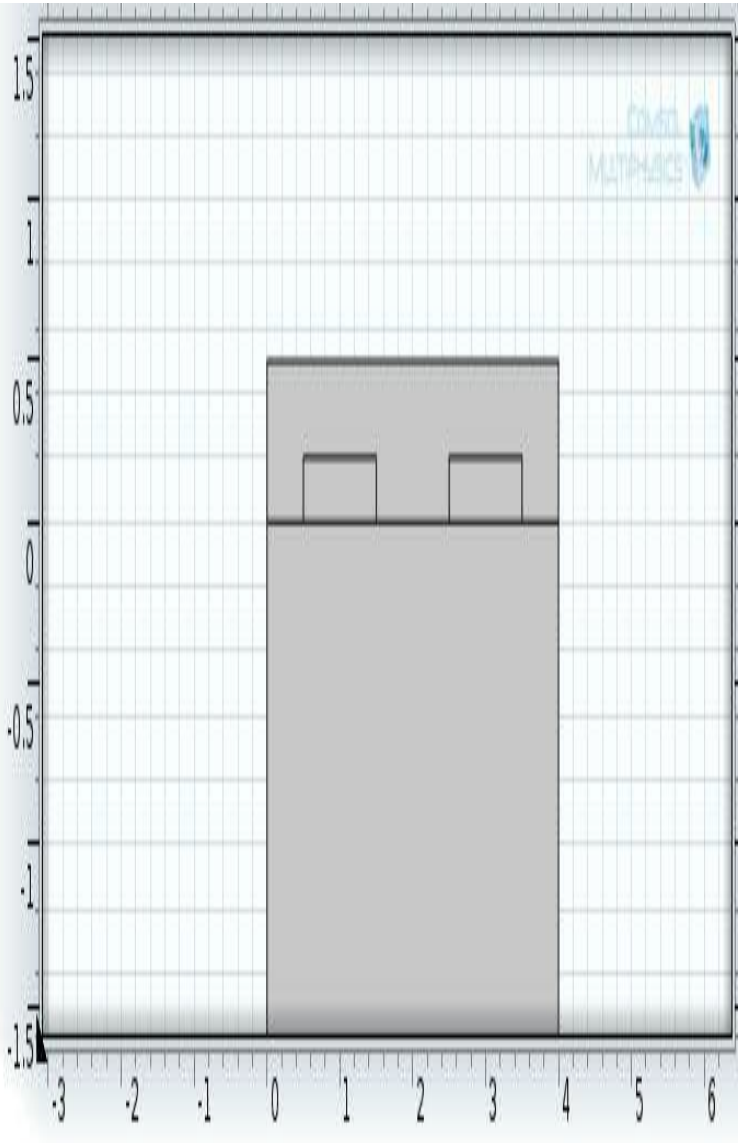
6. Model Design



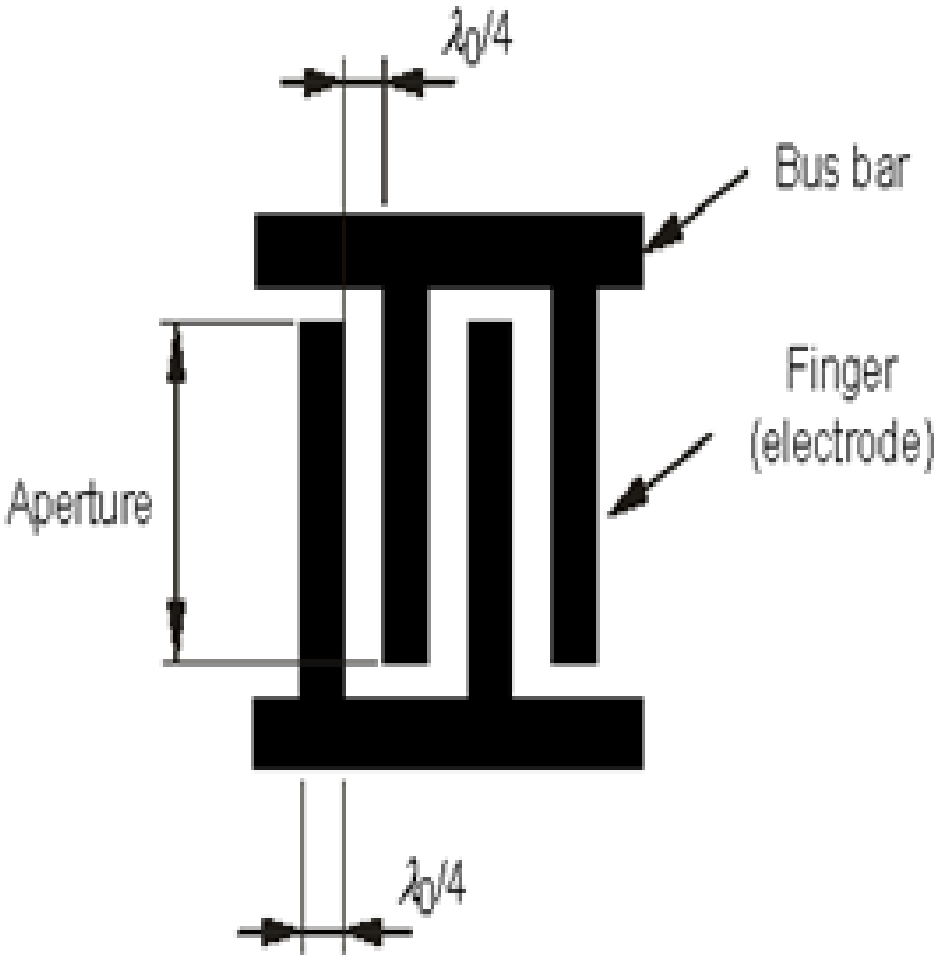
Conventional 3D Model



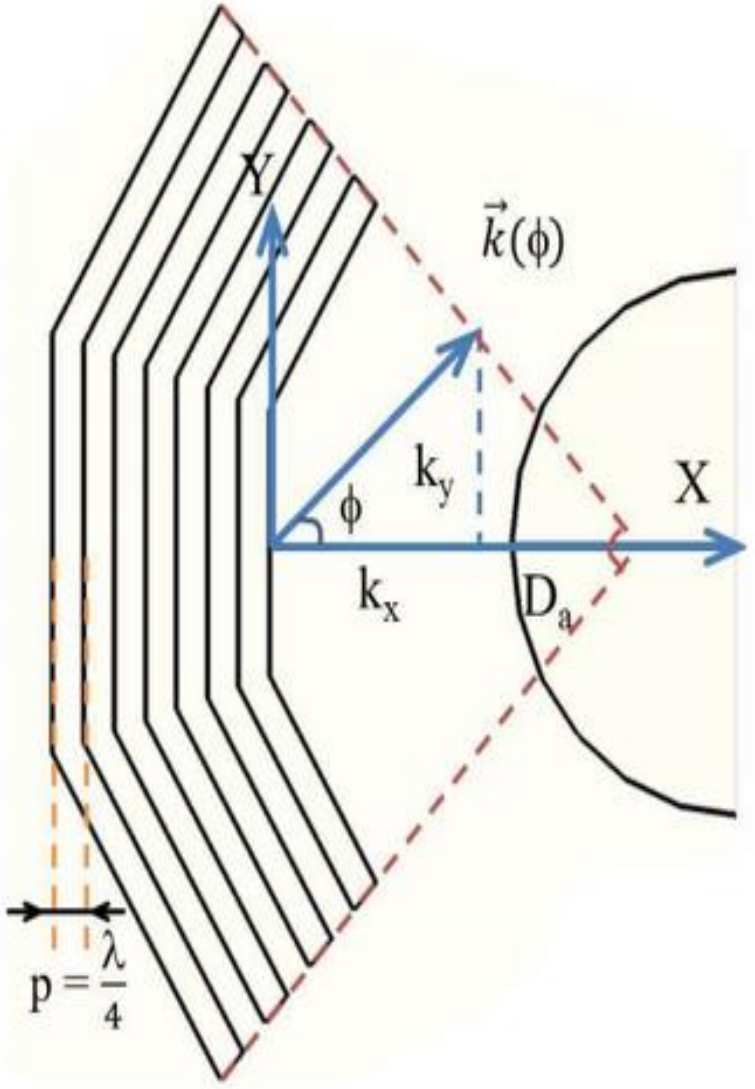
3D cut model



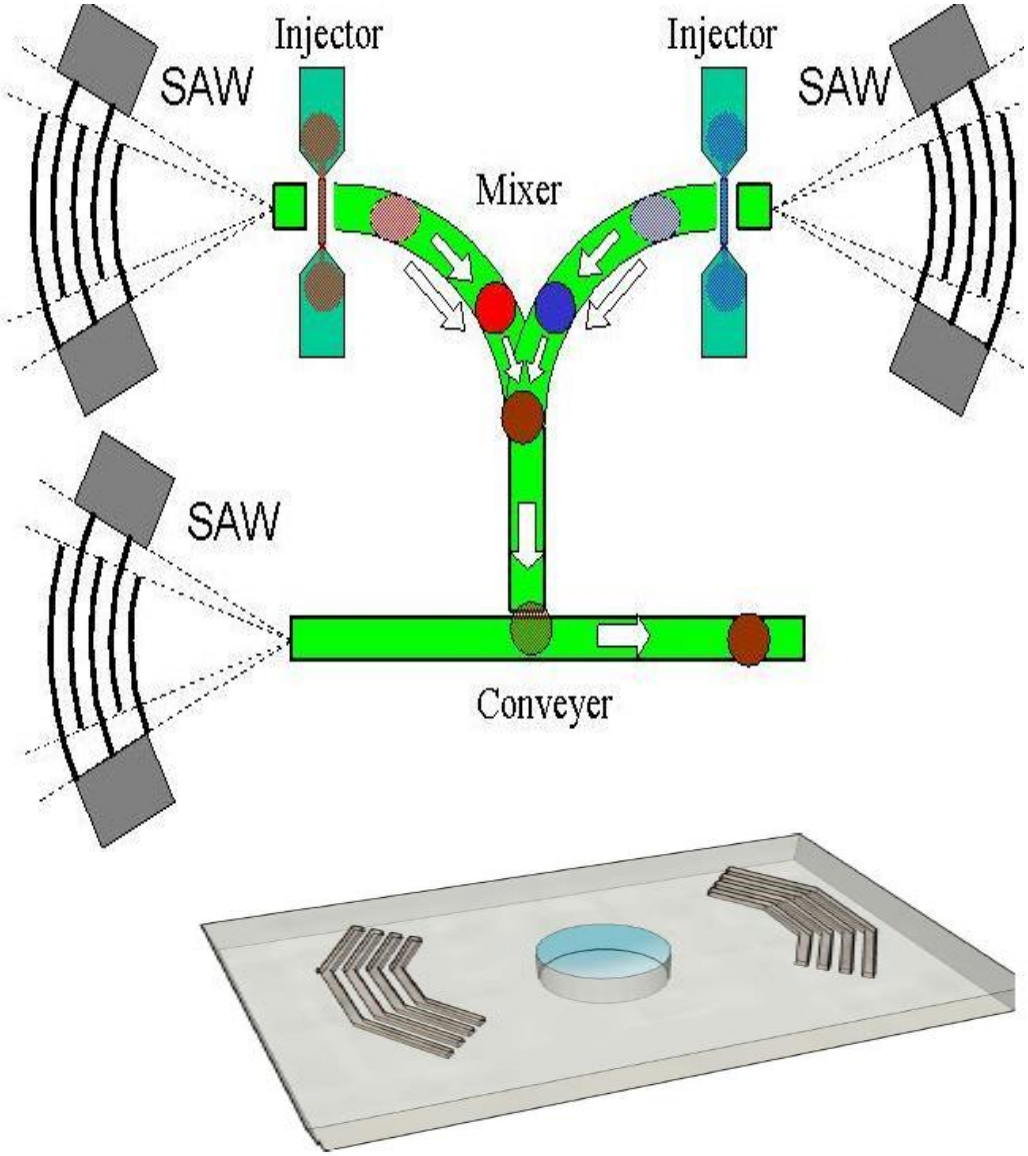
2D Base Model

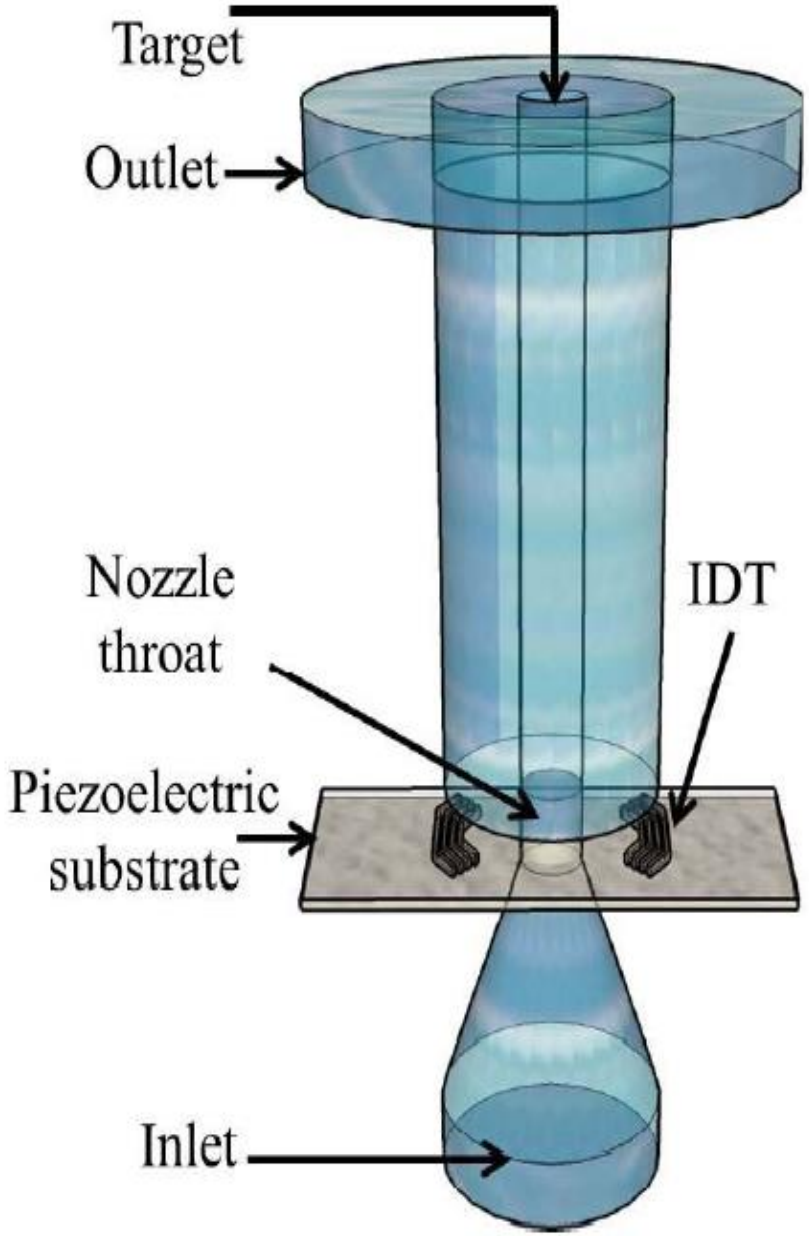


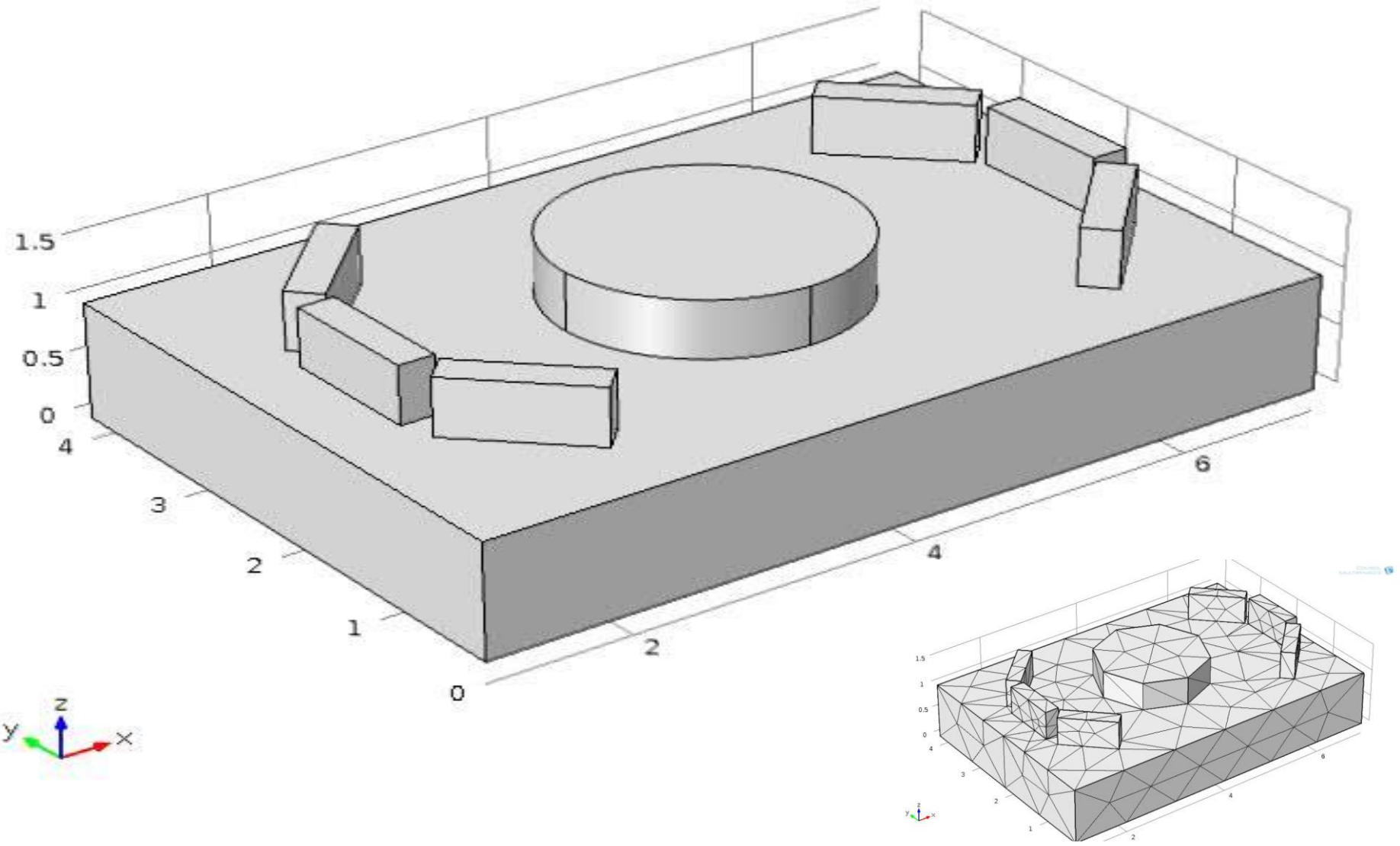
Conventional Design of IDT



Focused Design of IDT


Injector
Injector
SAW
SAW
Mixer
SAW
Conveyer


Target
Outlet
Nozzle
throat
IDT
Piezoelectric
substrate
Inlet

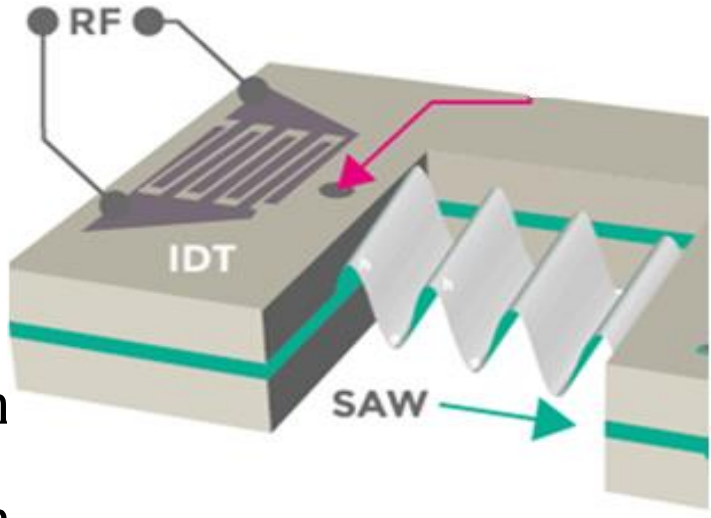


Modeled SAW sensor design using FIDT

Excerpt from the Proceedings of the COMSOL Conference 2015 PUNE.

Materials:

- Rectangular shaped electrodes made of **Aluminum**.
- Covered with **Polyisobutylene** (PIB) film.
- **Lithium Niobate** (LiNbO3) piezoelectric substrate.
- **Dichloromethane** (DCM)- CH2CL2 gas.



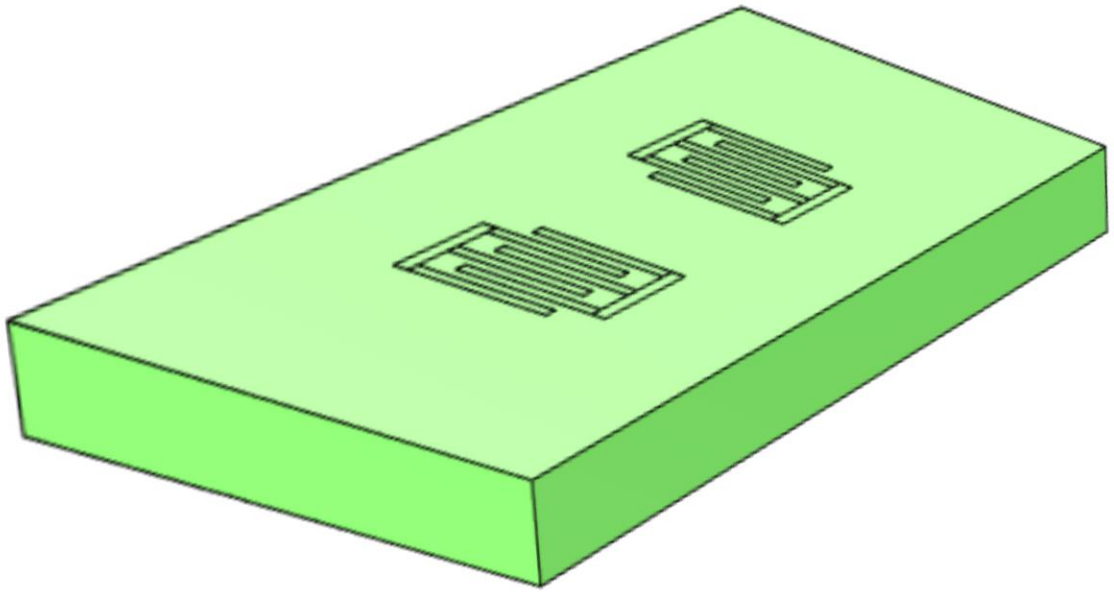
Dimensions:

- Substrate dimensions 6 μm x 4 μm x 1 μm
- PIB material of radius 1 μm, height 0.5 μm
- Electrode dimensions are 0.25 μm x1 μm x 0.5 μm.

Description	Expression	Value
Air pressure	p	101.325[kPa]
Gas constant	R	8.3145[Pa*m^3/(K*mol)]
DCM concentration in air	c_DCM_air	100e-6*p/(R*T)
Molar mass of DCM	M_DCM	84.93[g/mol]
PIB/air partition constant for DCM	K	30.346
Mass concentration of DCM in PIB	rho_DCM_PIB	0.010534kg/m^3
Density of PIB	rho_PIB	918.00kg/m^3
Young's modulus of PIB	E_PIB	10[Gpa]
Poissons ratio of PIB	nu_PIB	0.48
Relative permittivity of PIB	eps_PIB	2.2

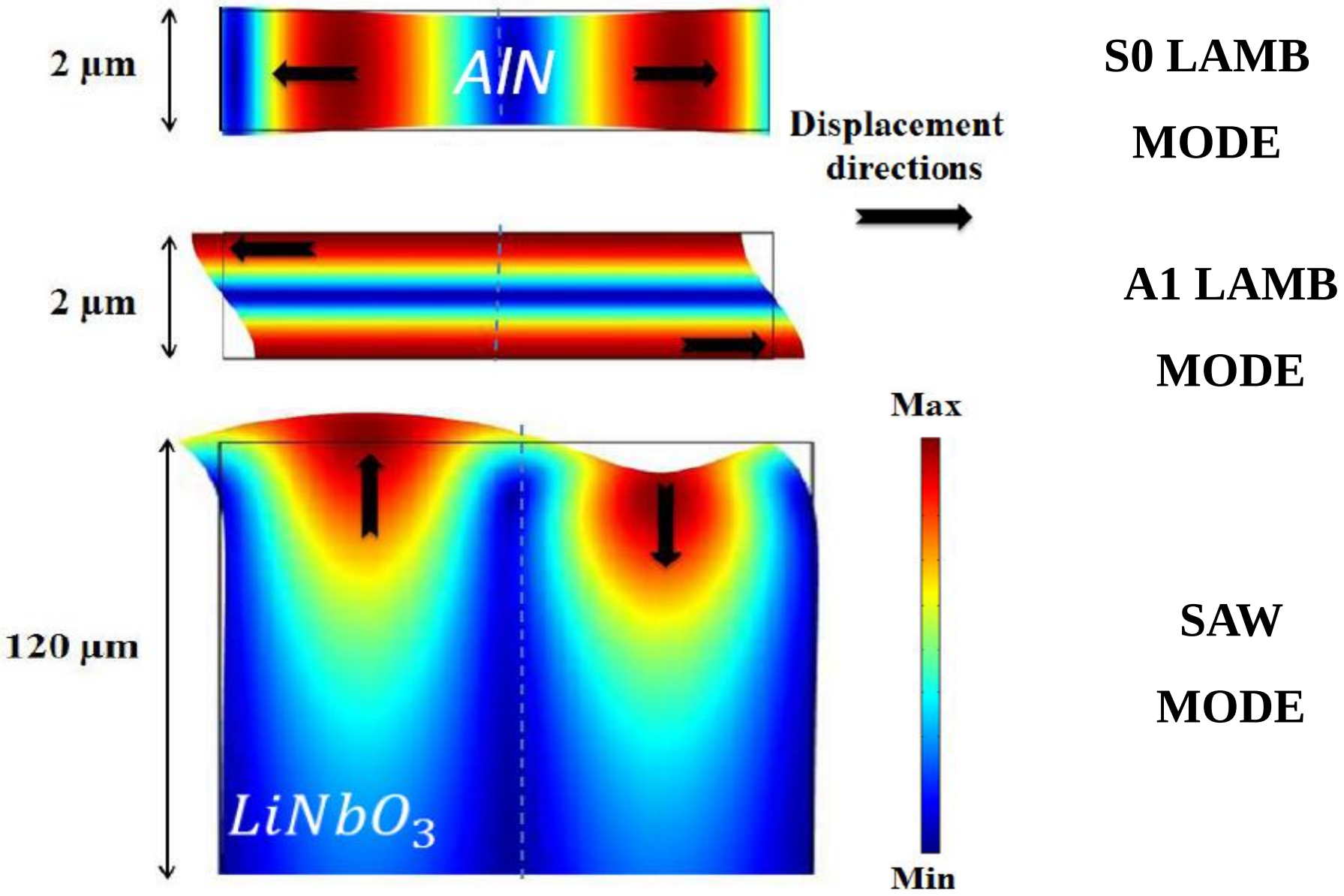
7. Simulation

- Analysis of Surface Deformation.

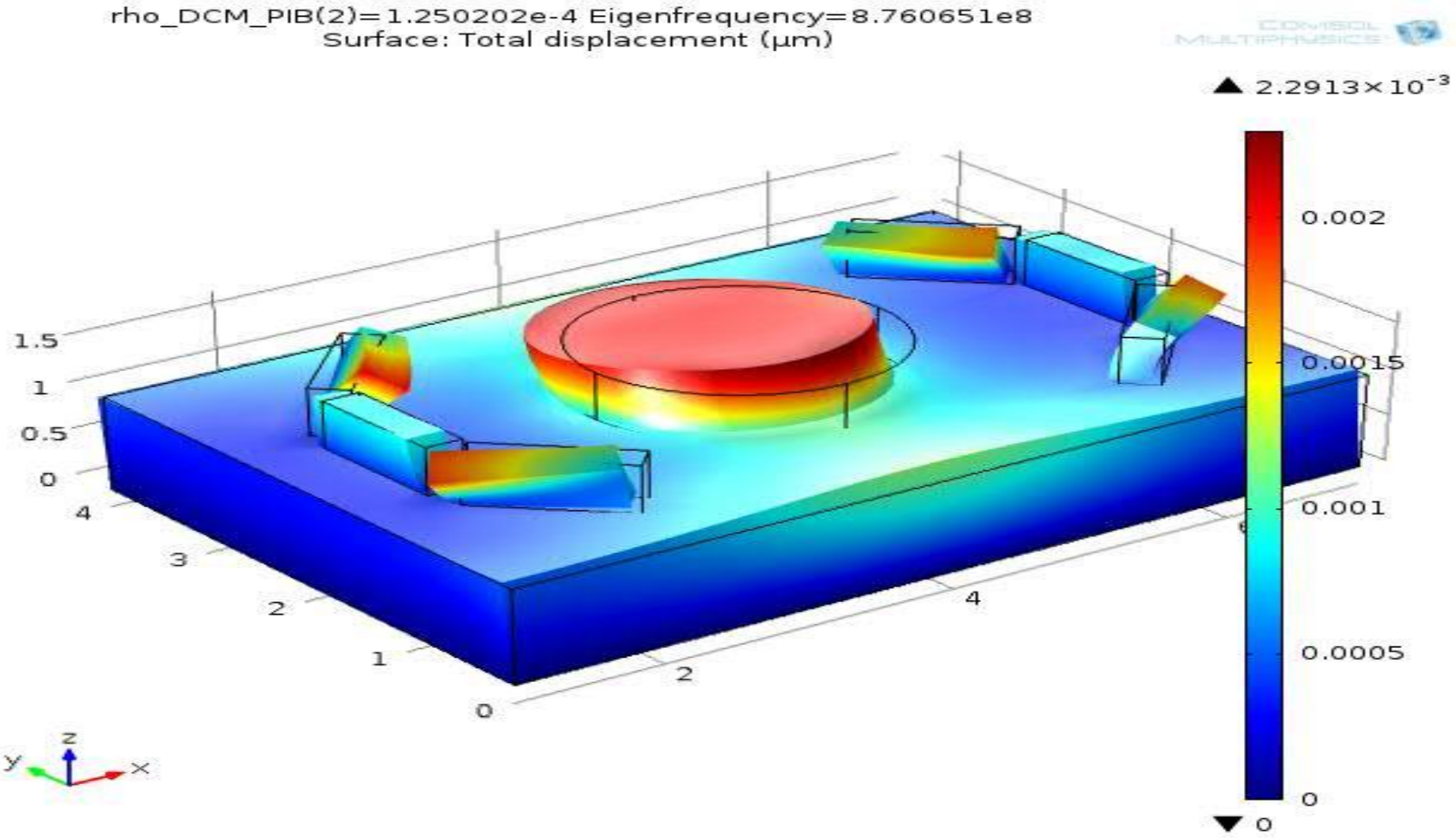


- Calculation of Electrical Potential.

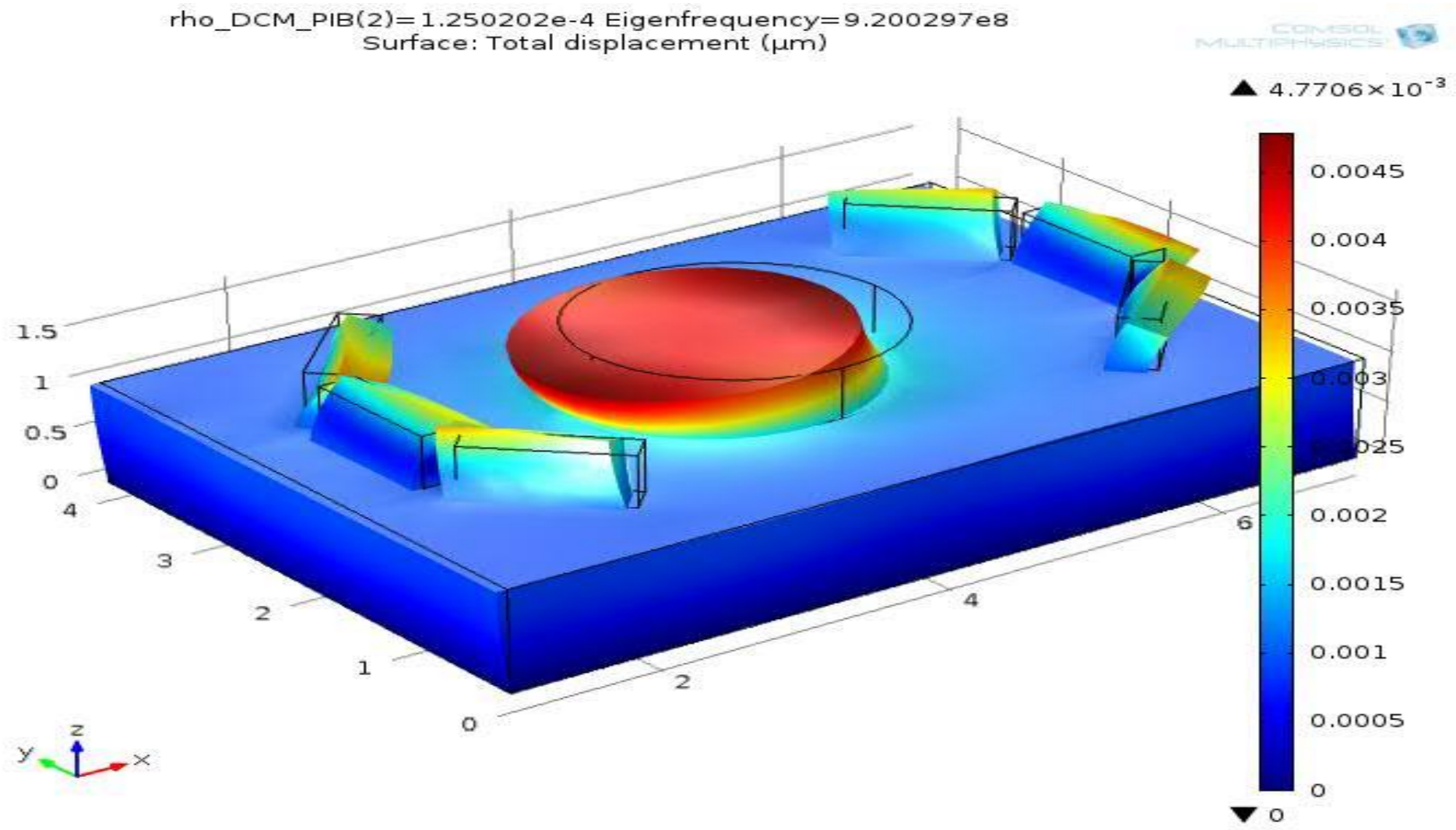
Modes of propagation:



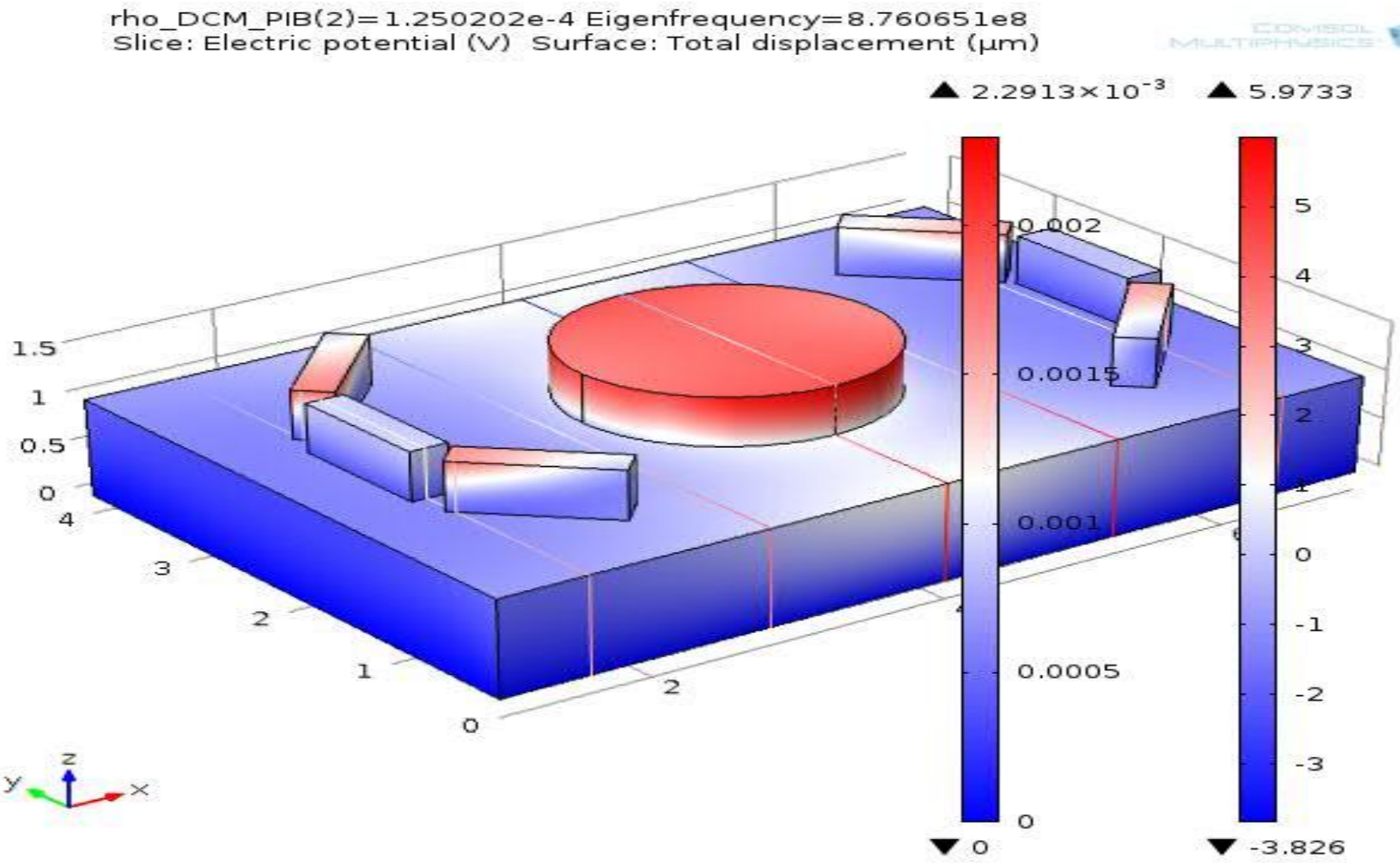
8. DISCUSSION



Deformed shaped plot of SAW model at Resonance.

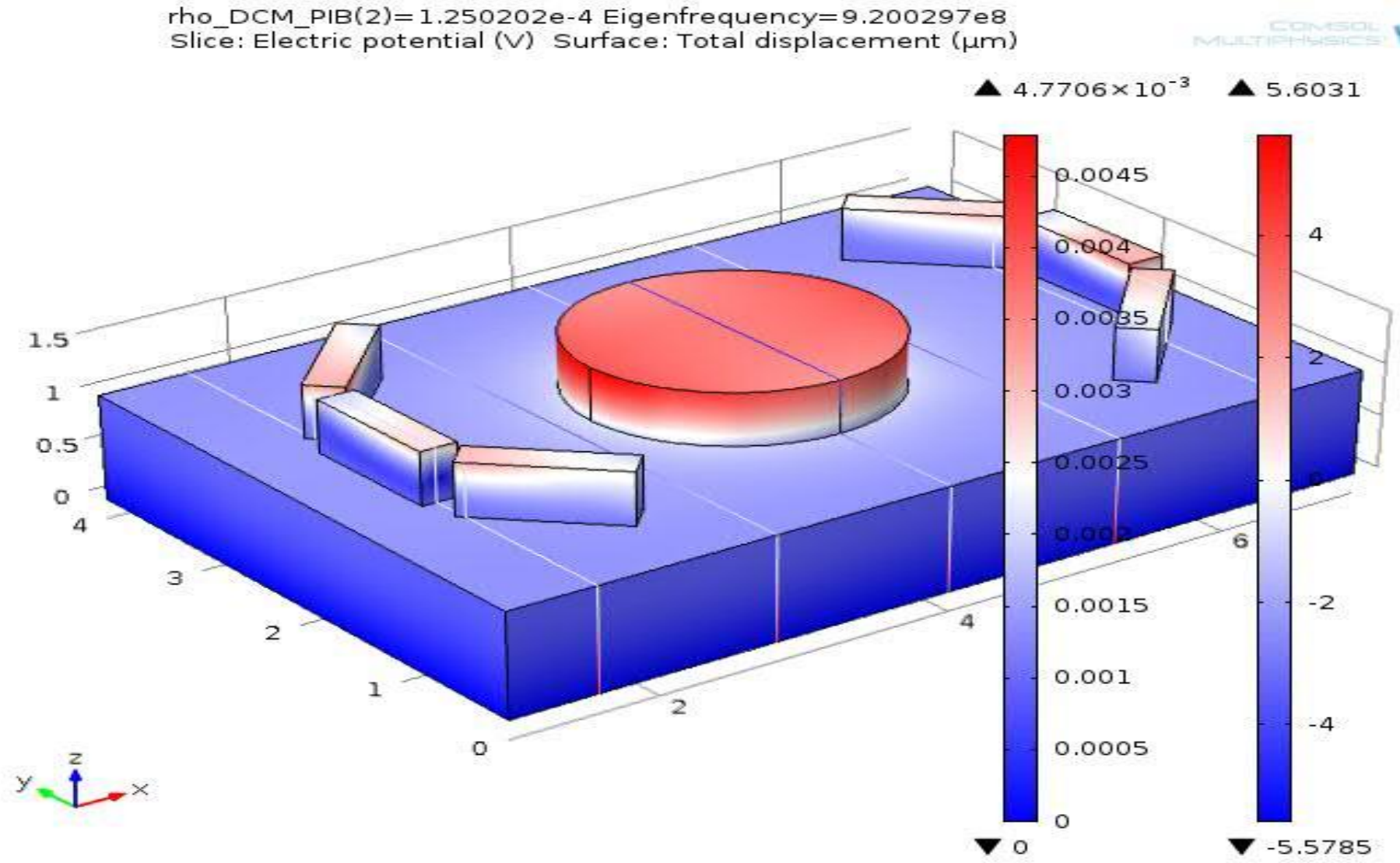


Deformed shaped plot of SAW model at Anti-Resonance.



Electric potential distribution at Resonance.

Excerpt from the Proceedings of the COMSOL Conference 2015 PUNE.

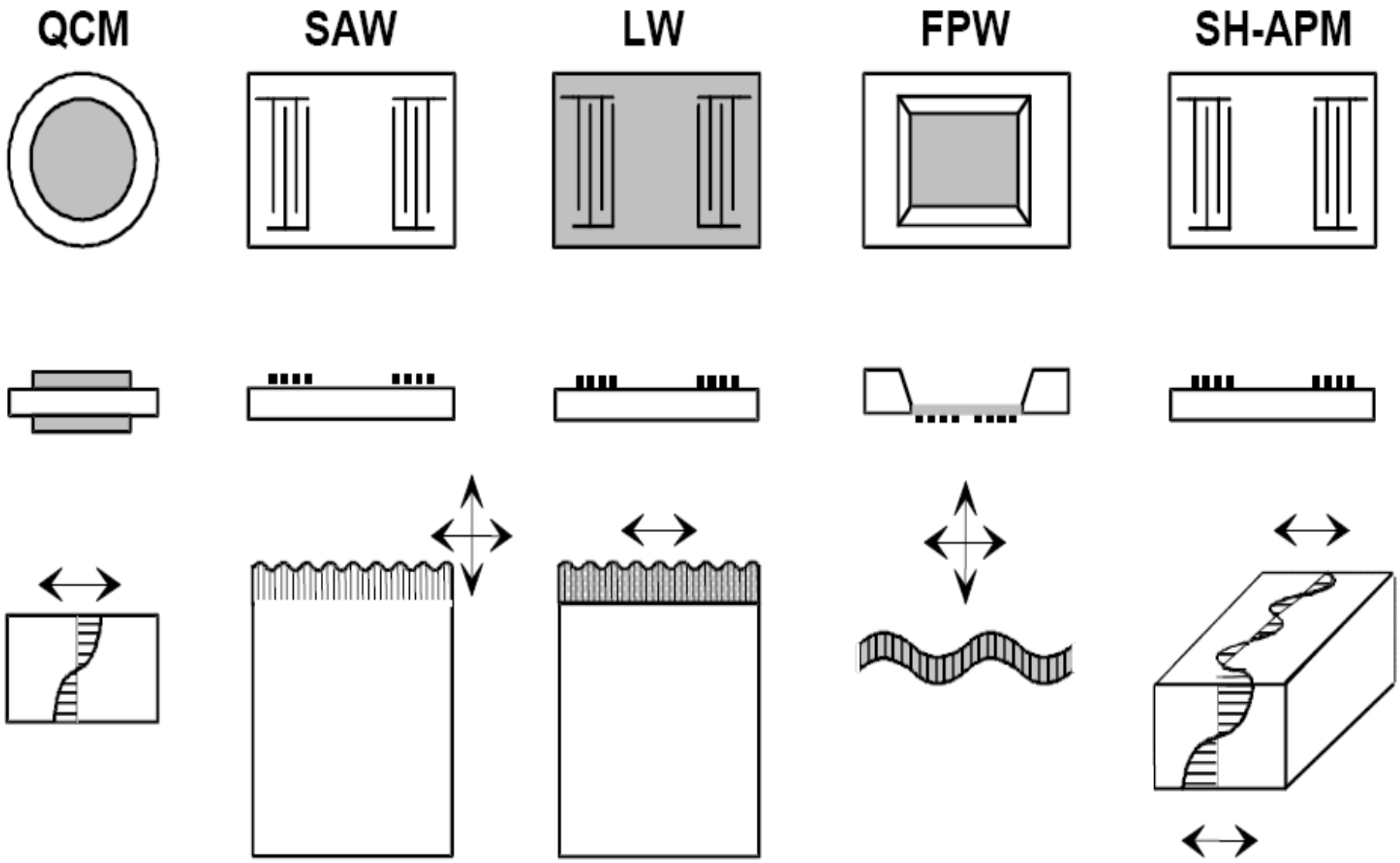


Electric potential distribution at Anti-Resonance.

Excerpt from the Proceedings of the COMSOL Conference 2015 PUNE.

9. RESULTS

Parameter	Focused IDT Model	Conventional Model
Surface Displacement at Resonance	2.2193 X 10^{-3}	1.855 X 10^{-3}
Surface Displacement at Anti - Resonance	4.7706 X 10^{-3}	2.487 X 10^{-3}
Electrical Potential at Resonance	5.9733	5.9748
Electrical Potential at Anti - Resonance	5.6031	5.3614

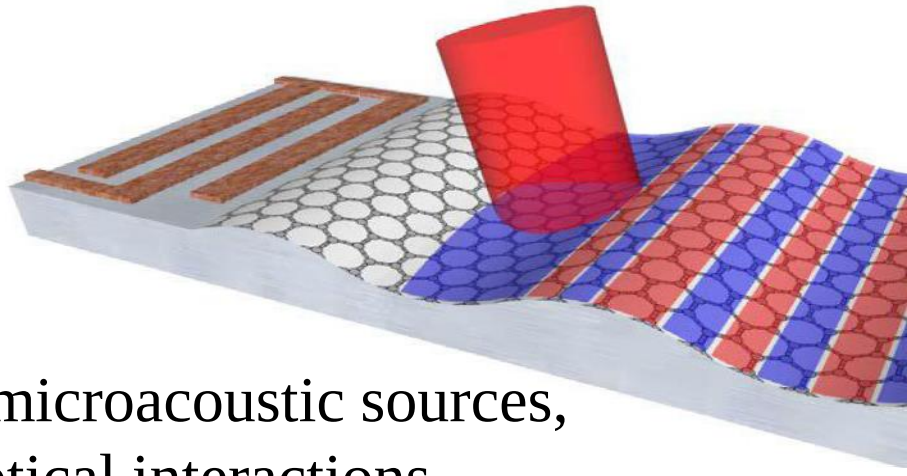

QCM
SAW
LW
FPW
SH-APM

10. CONCLUSION

➢ MEMS based SAW gas sensor is designed using Focused-IDT design for analysis of the resultant characteristics in a 3D model.

➢FIDT design helps in concentration of more amount of acoustic energy on to the poly chemical coating layer.

➢Enhanced results reflected the utility of this as an industrial gas sensor with better sensitivity.



➢Significant to design new intense microacoustic sources, for instance for enhanced acouto-optical interactions.

THANK YOU

COMSOL
CONFERENCE
2015 PUNE