Electrode Design for Efficient Excitation of Vibrational Modes in an AlN based PMUT

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1. INTRODUCTION

Piezoelectric micromachined ultrasound transducers (PMUTs) are gaining interest as miniaturized devices for applications such as medical imaging and particle manipulation.[1]

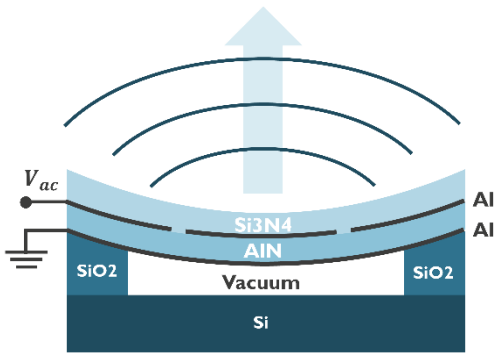

Figure 1. Schematic depiction of a PMUT

For some applications, high output power is desired and operation at different vibrational modes could be an interesting feature. This work investigates top electrode design for efficient excitation of the first four vibrational modes in a circular PMUT.

2. COMPUTATIONAL METHODS

Top electrode designs are proposed for each vibrational mode. Configurations with single- and out-of-phase actuation are investigated. A nested sweep in a frequency domain study is performed to extract optimal electrode dimensions and resonance frequencies in both water and vacuum for several membrane diameters. Designs are optimized for high output power at a given input voltage.

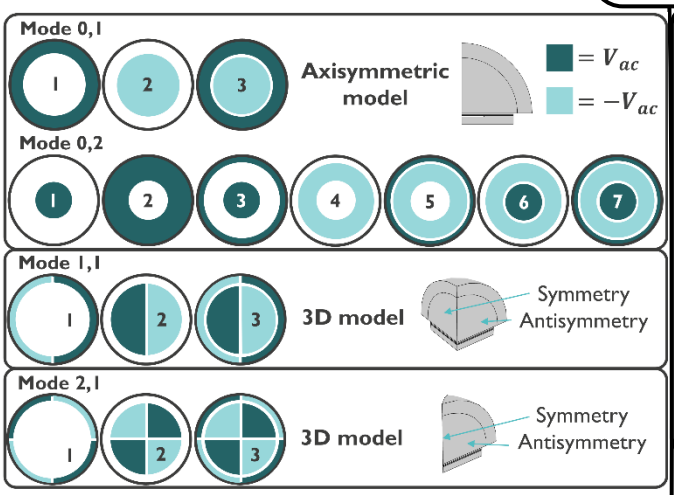

Figure 2. Investigated top electrode configurations for each mode

3. RESULTS

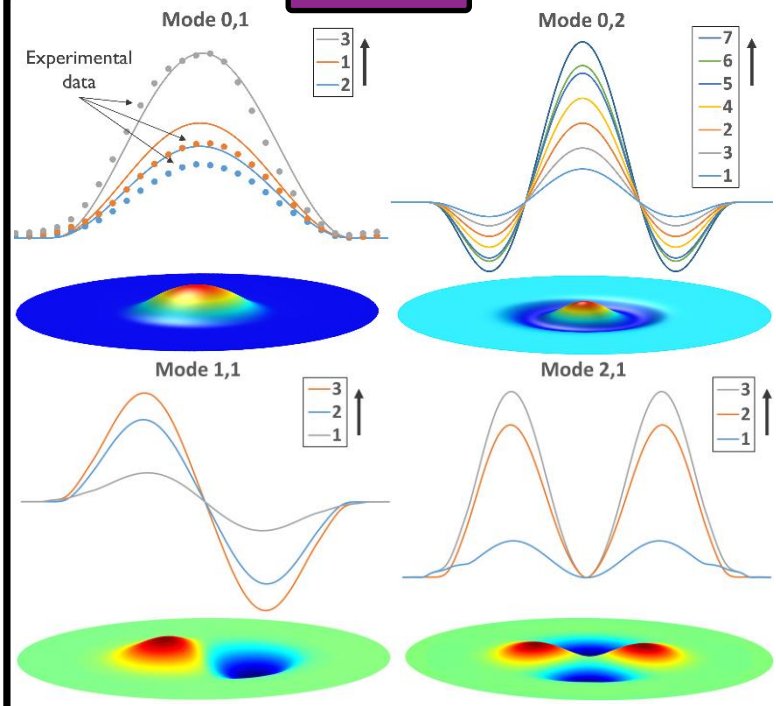

Figure 3. Normal displacement for each electrode design and four vibrational modes

Table 1. Summary of the simulation results

Mode	Parameters		Optimal design			
	Electrode coverage		Single phase		Dual phase	
	$\frac{R_{inner\ electrode}}{R_{cavity}}$	$\frac{R_{outer\ electrode}}{R_{cavity}}$		Extended[2]		Extended[2]
0,1	$0.67 - 0.72$		2	1	3	3
0,2	$0.40 - 0.47$	$0.86 - 0.91$	4	4	6[1]	7
1,1	$0.80 - 0.83$				2[1]	3
2,1	$0.85 - 0.89$				2[1]	3

1. An insignificant improvement can be made by introducing the outside rings on these designs
2. Top electrode extends further than the vacuum cavity

4. CONCLUSIONS

- Experimental measurements confirm that a significant increase in output power is achieved by utilizing out-of-phase excitation.
- Making the top electrode larger than the cavity size can increase output power for designs that contain a top electrode on the cavity edge.
- Small deviations in optimal electrode dimensions may be attributed to changes in the mechanical and/or acoustic domain.
- Future simulation work may study the effect of more realistic electrode connections.

REFERENCES:

1. Qiu, Yongqiang, et al., Piezoelectric micromachined ultrasound transducer (PMUT) arrays for integrated sensing, actuation and imaging, *Sensors*, 15.4: 8020-8041

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