Acoustic Crosstalk Reduction Method for CMUT Arrays

Baris Bayram, Goksen G. Yaralioglu,
Mario Kupnik, and Butrus T. Khuri-Yakub

Ginzton Laboratory, Stanford University, CA

2006 IEEE Ultrasonics Symposium, Vancouver, Canada

Outline

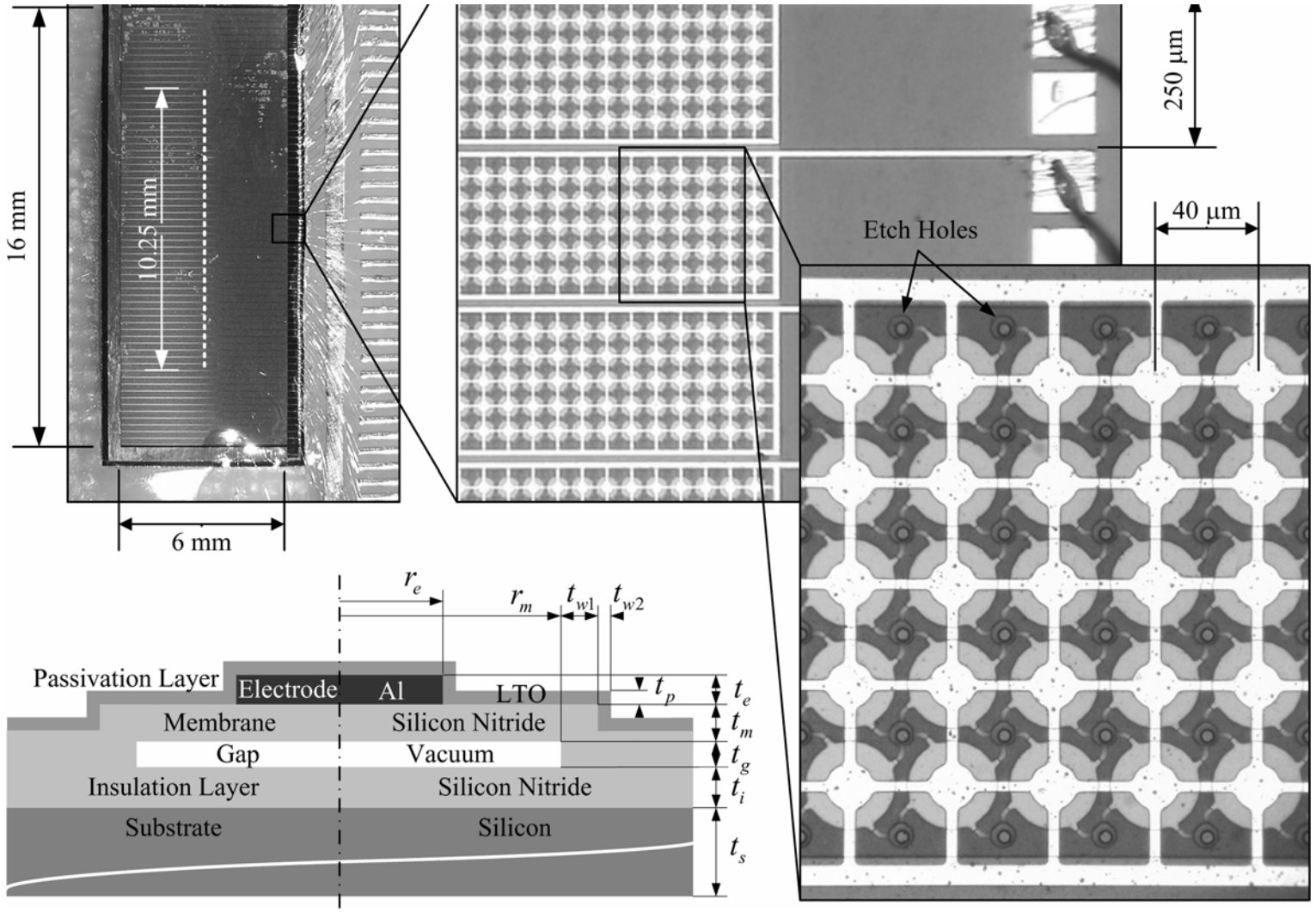
- Motivation
- Finite element (FE) analysis of a 1-D CMUT array
- Experimental verification
- A new method to reduce crosstalk
- Conclusion

Motivation

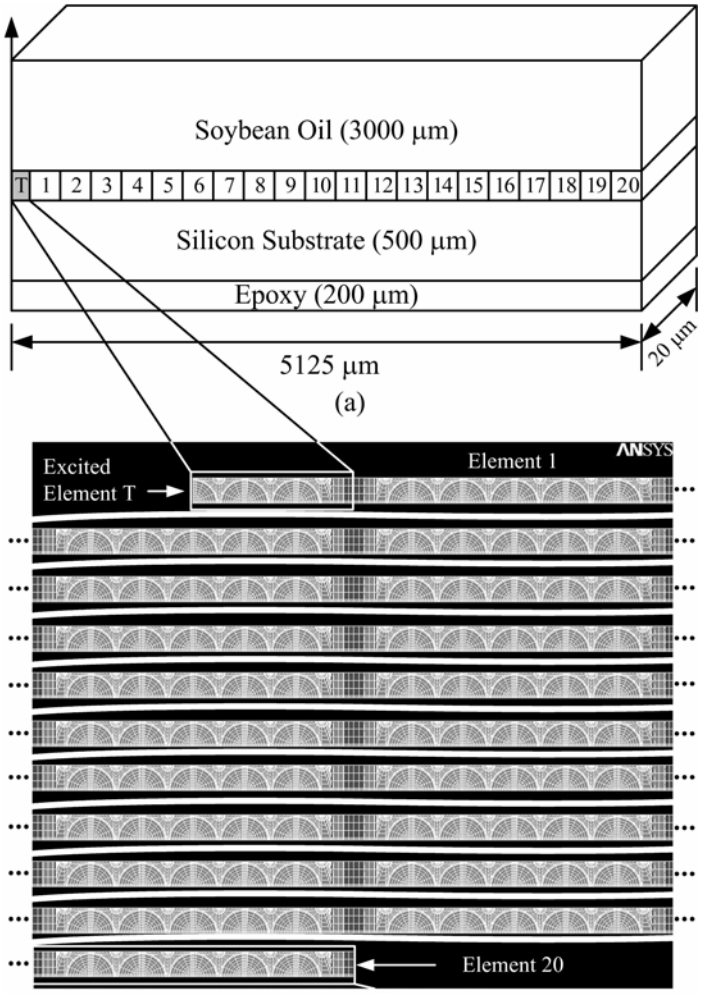
- To accurately model the crosstalk in CMUT arrays in “linear” and nonlinear operation regimes using time-domain, finite element method (FEM)

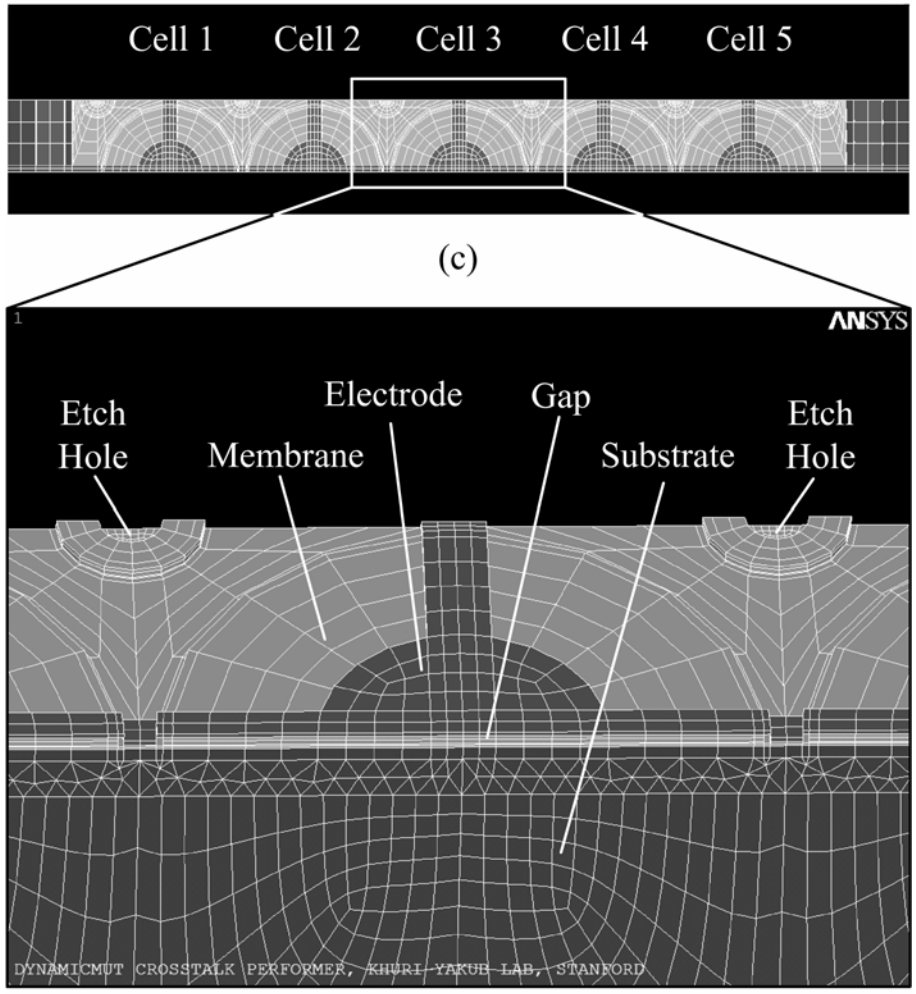
- To reduce the crosstalk between array elements using FEM to explore novel methods

1-D CMUT Array



Finite Element Model of the Array

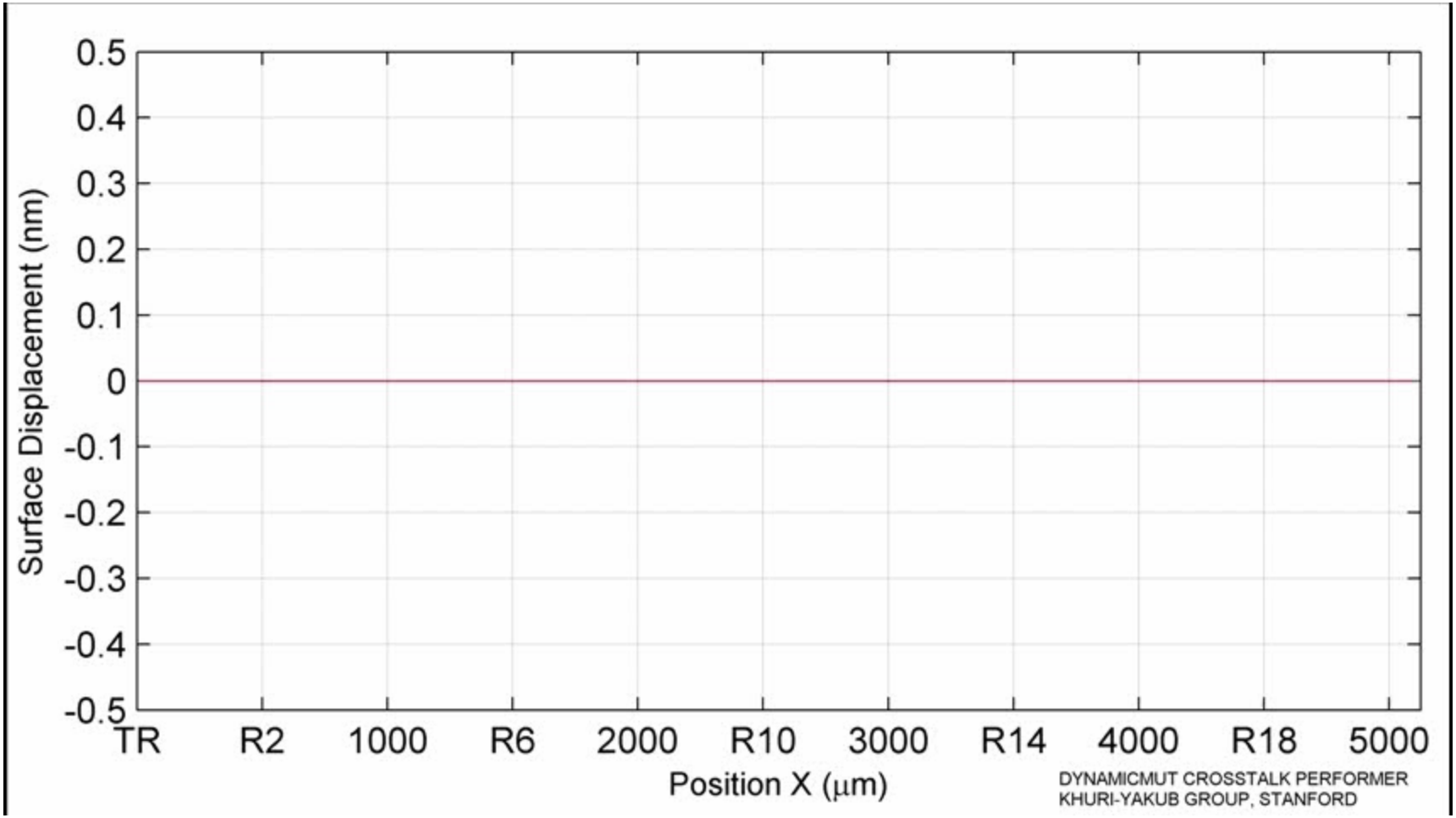




Features of the FE Analysis

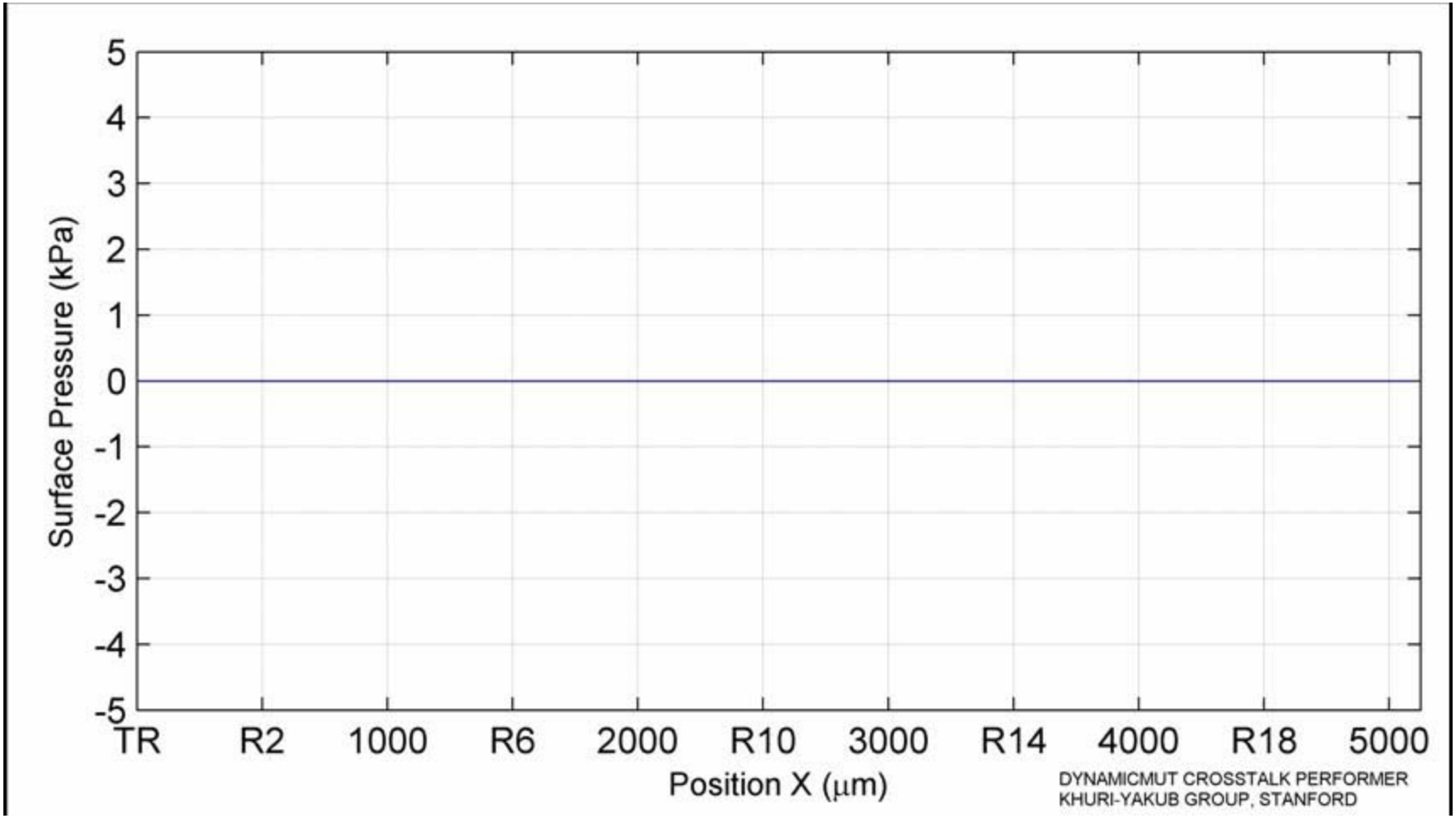
- Explicit, time-domain solver of a commercially available software (***LS-DYNA 970***)
  - 3-D modeling of an actual CMUT array in detail
  - Memory-efficient, faster calculations for large million-node models
- Electrostatic-structural coupling
  - Electromechanical transducer modeling of the CMUT
- Robust contact implementation
  - CMUT modeling in collapsed and collapse-snapback nonlinear operation modes
- Fast, initial biasing of the CMUT array
  - 40 times faster results in biasing conventional or collapsed modes for a 20-element model
- Verification with interferometer measurement results for an identical CMUT array
  - Accurate and reliable FE results

Displacement across Neighbors



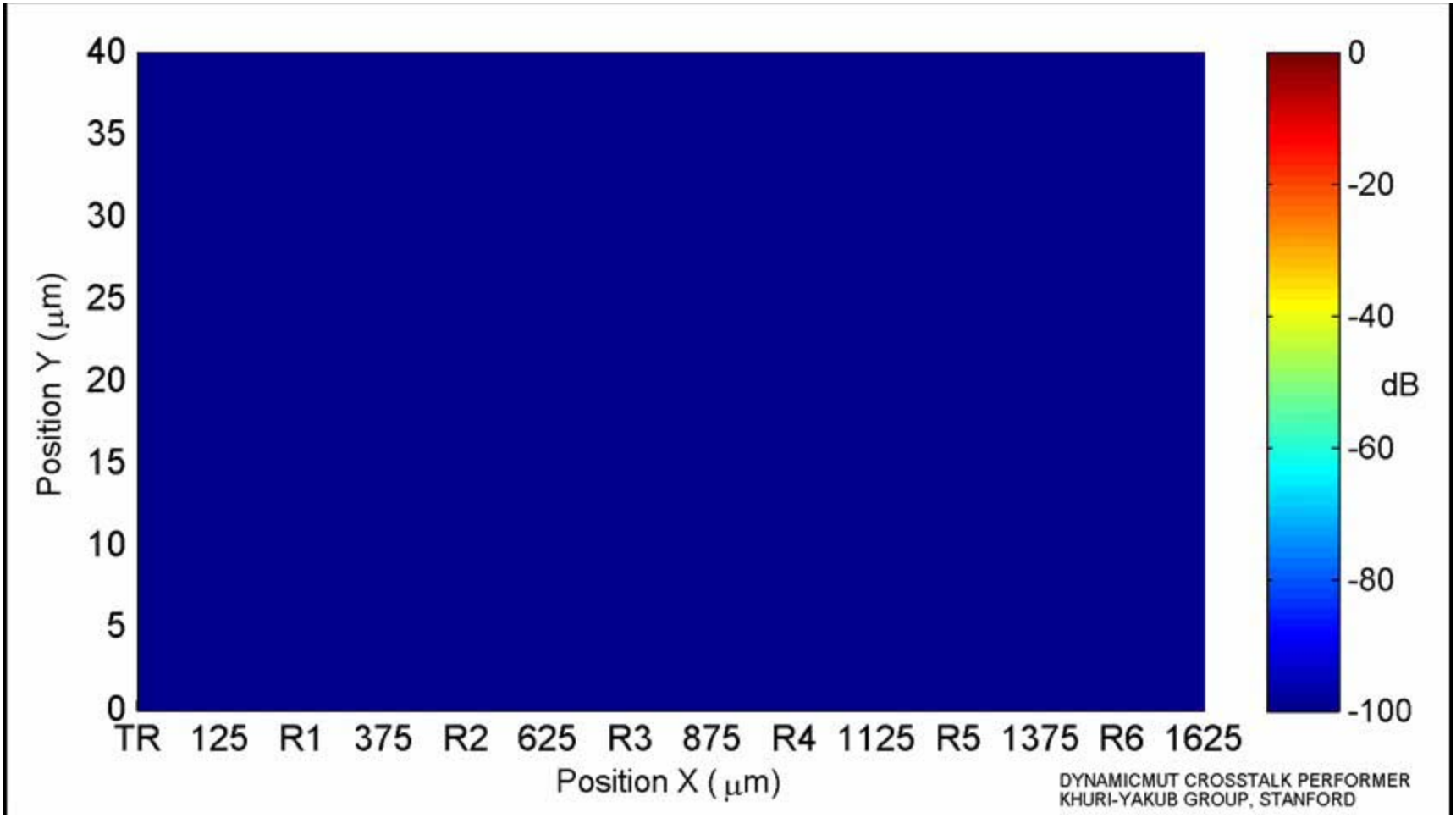
Conventional mode

Pressure across Neighbors



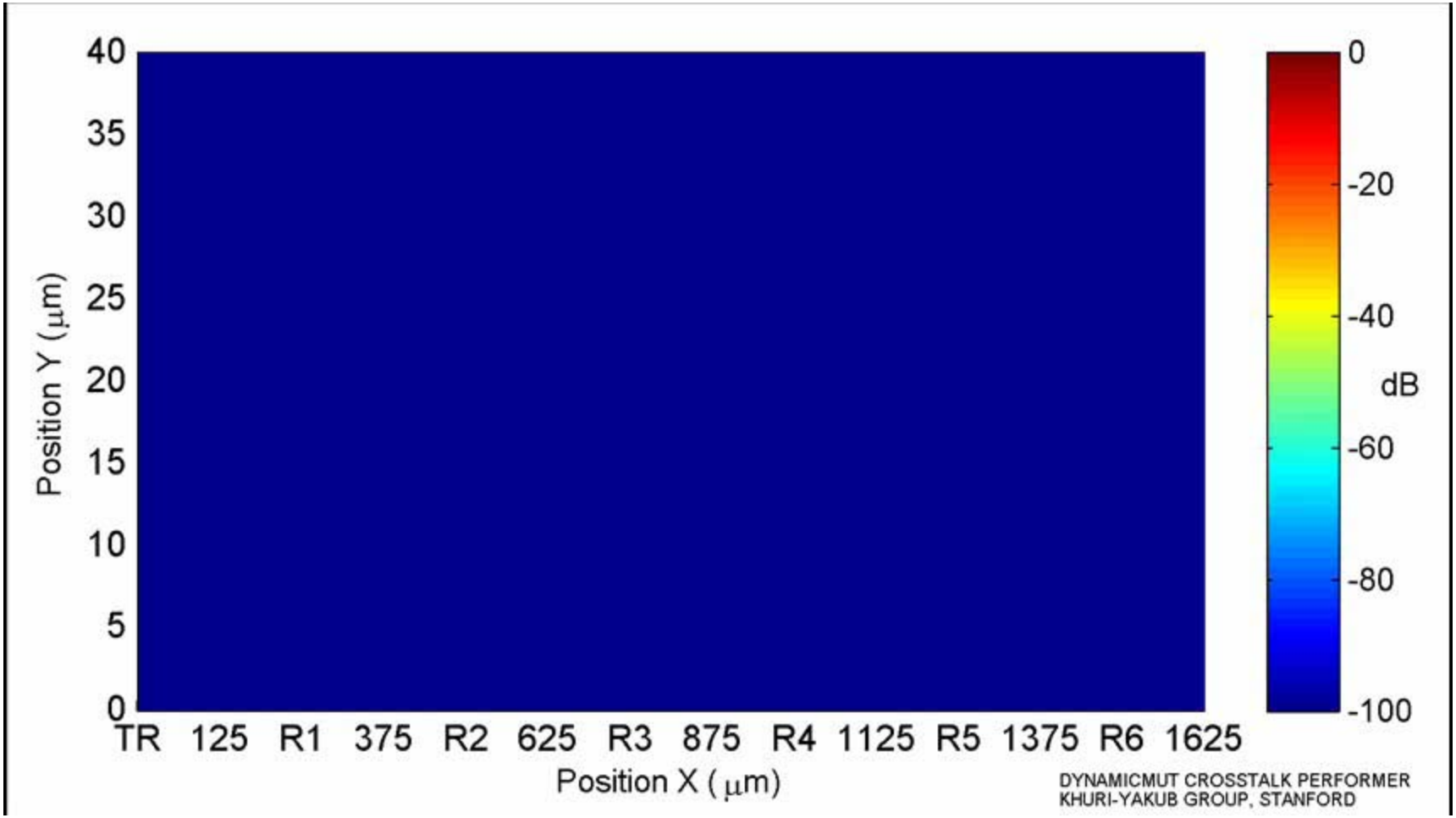
Conventional mode

Pressure Waves on the Surface



Conventional mode

Pressure Waves on the Surface

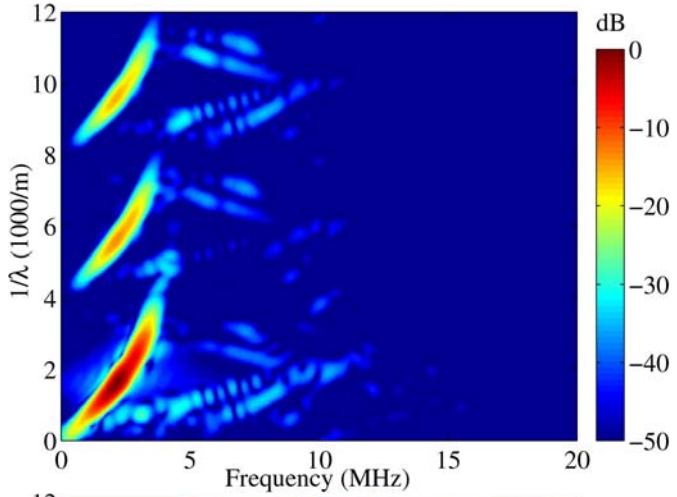


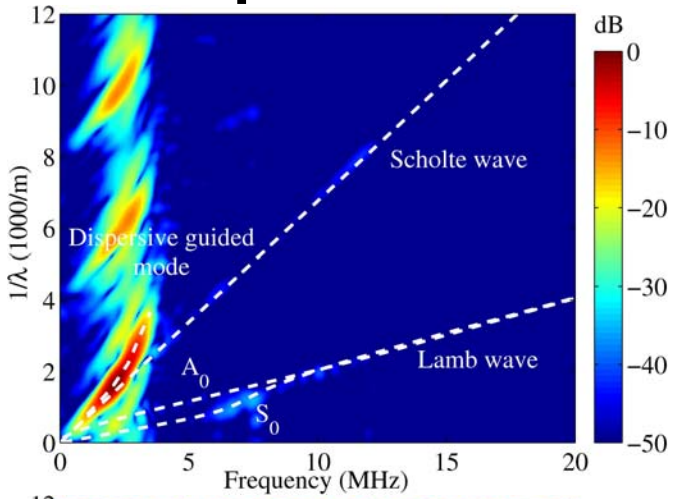
Collapsed mode

Experimental Verification

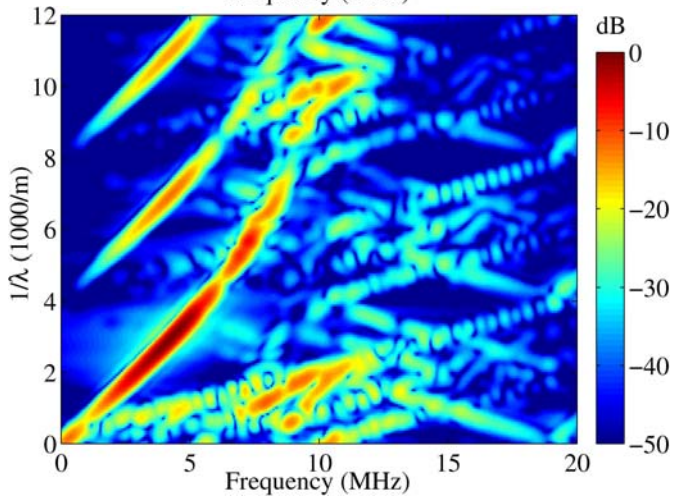
Simulation | **Experiment**

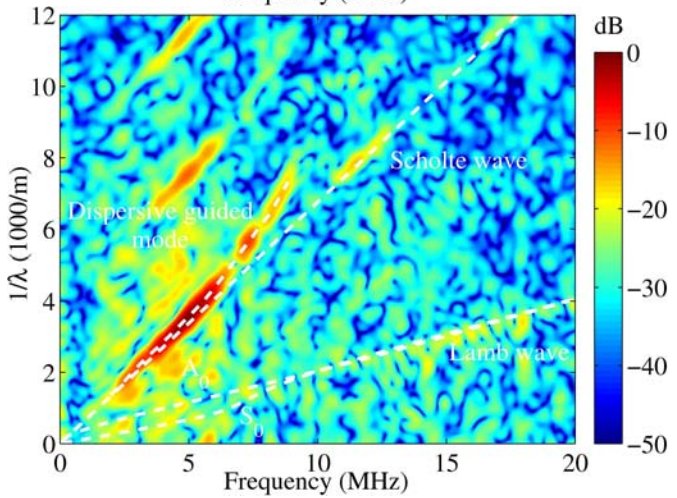
Conventional



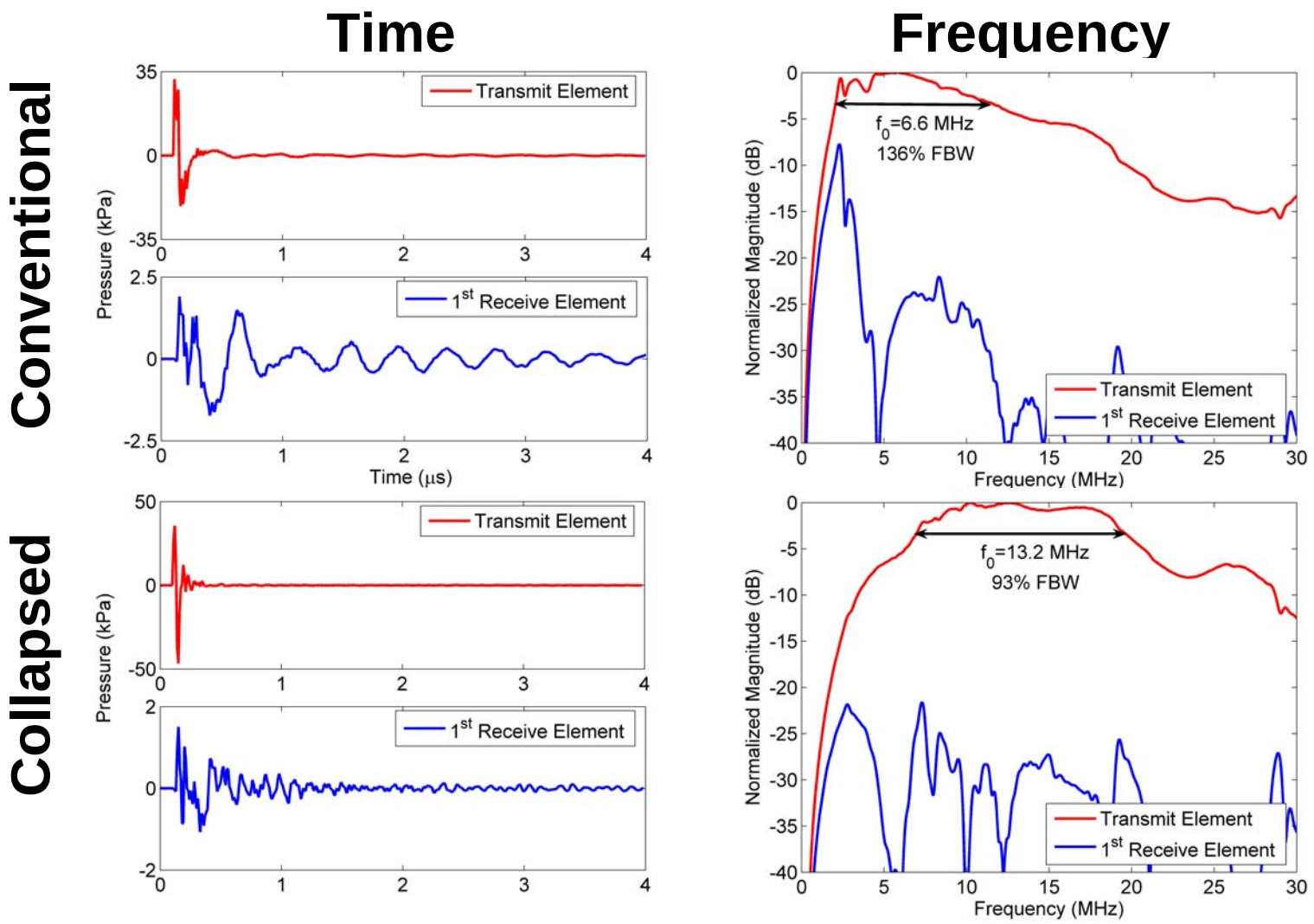


Collapsed



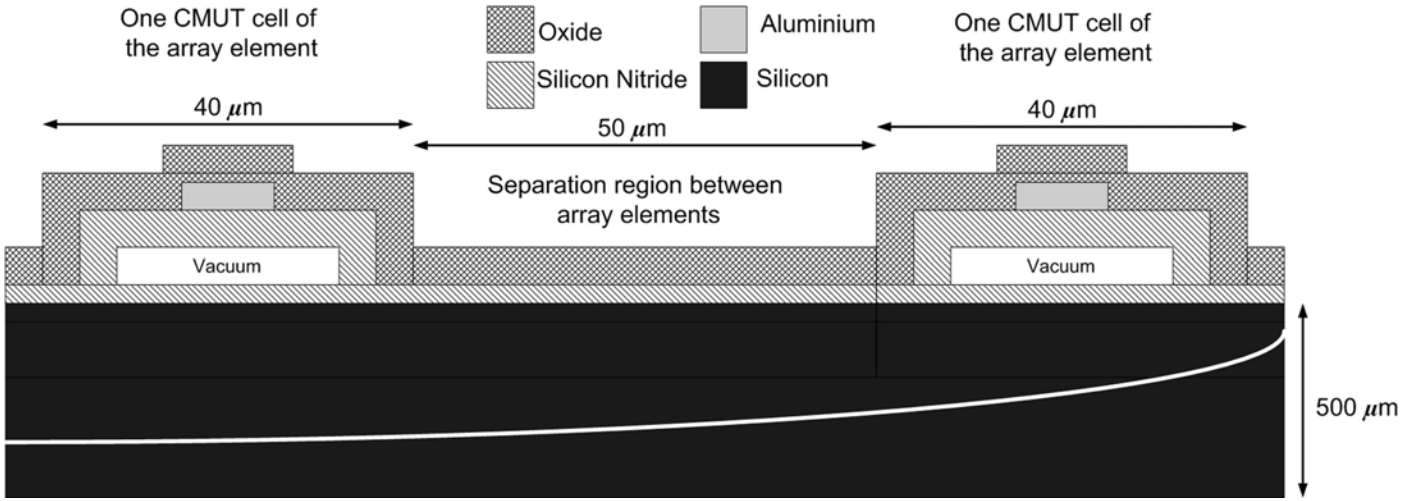


Dispersive Guided Modes

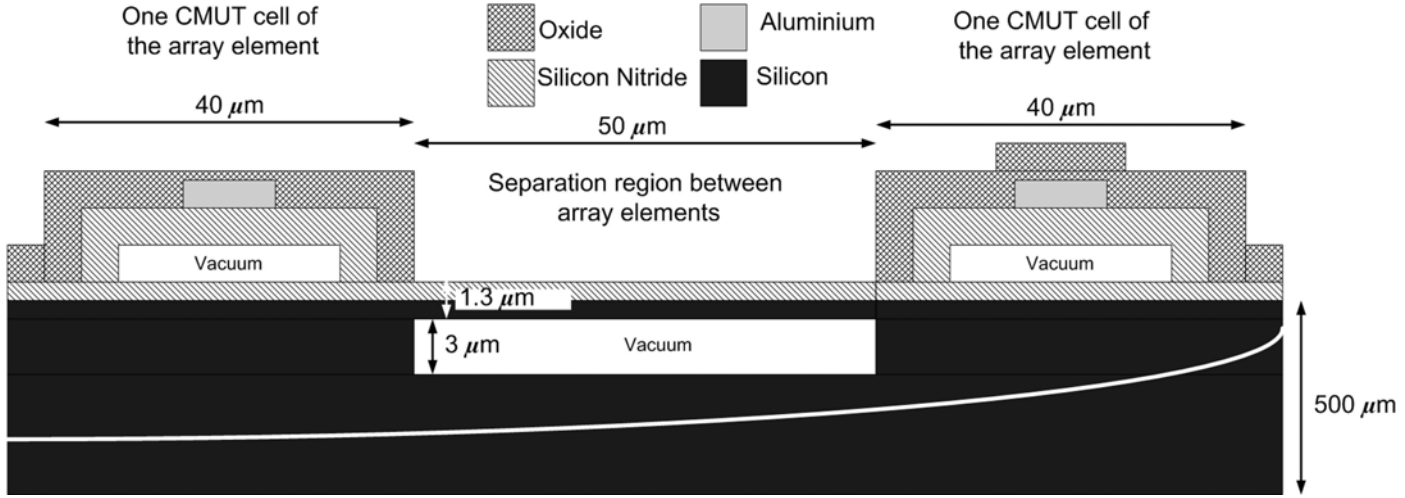


Crosstalk Reduction Method

Regular CMUT



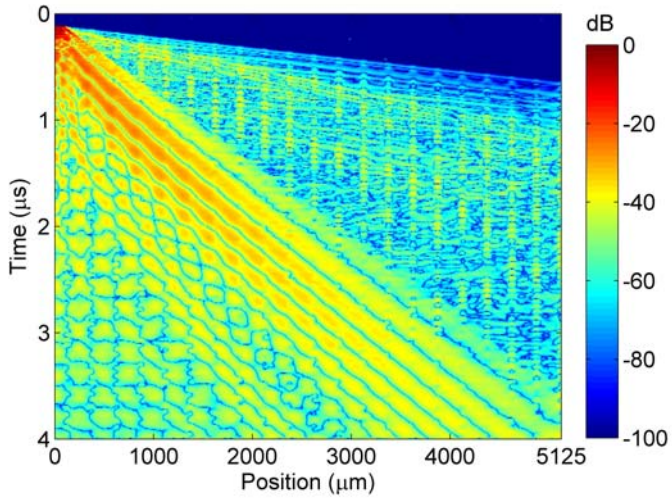
Modified CMUT

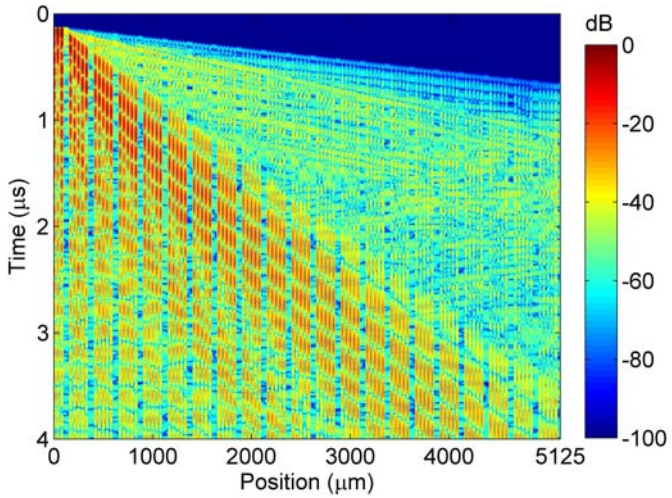


Reduced Crosstalk for the Modified CMUT

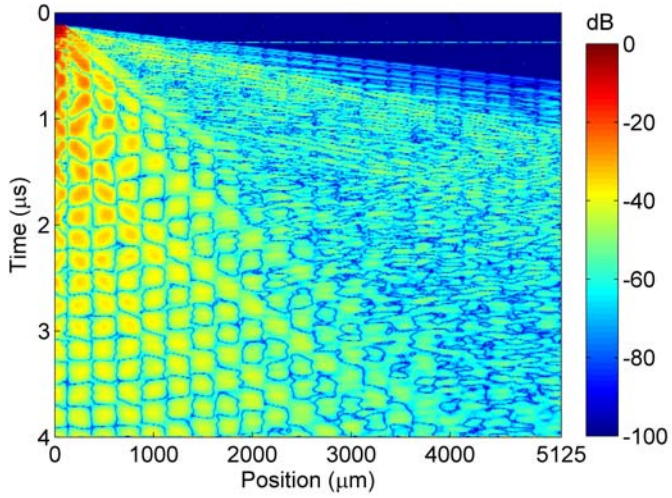
Pressure **Displacement**

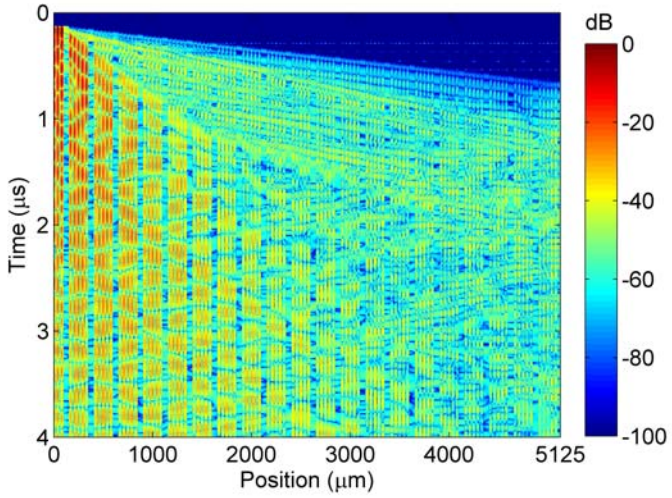
Regular CMUT



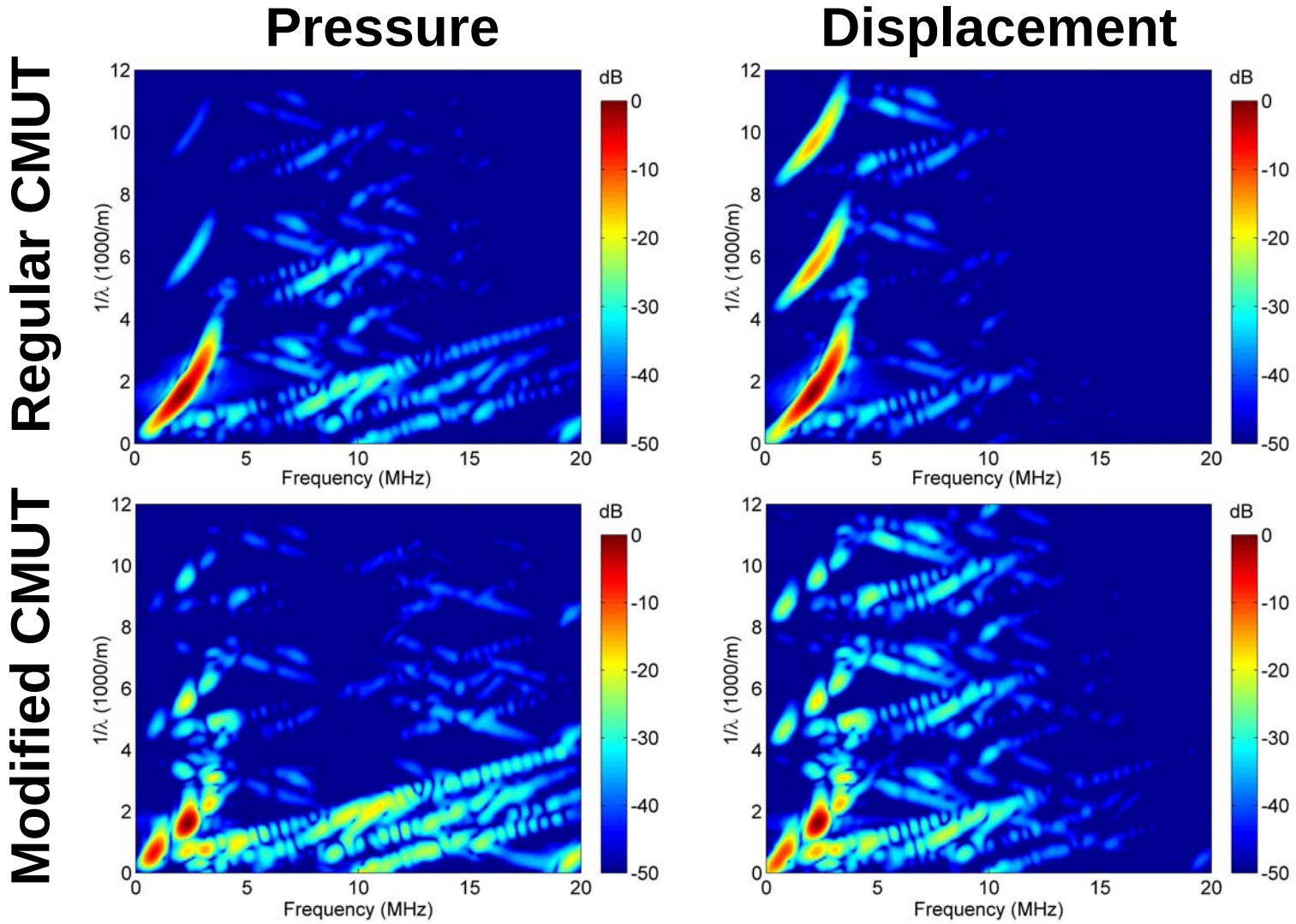


Modified CMUT



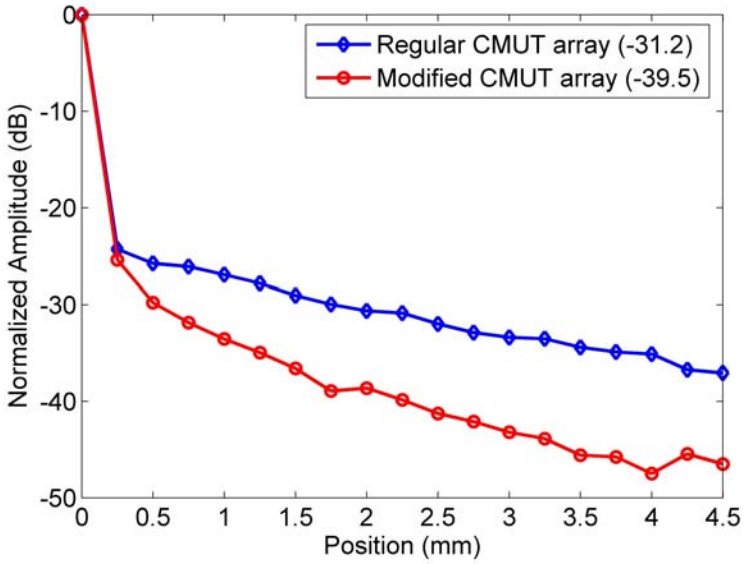


Reduced Crosstalk for the Modified CMUT

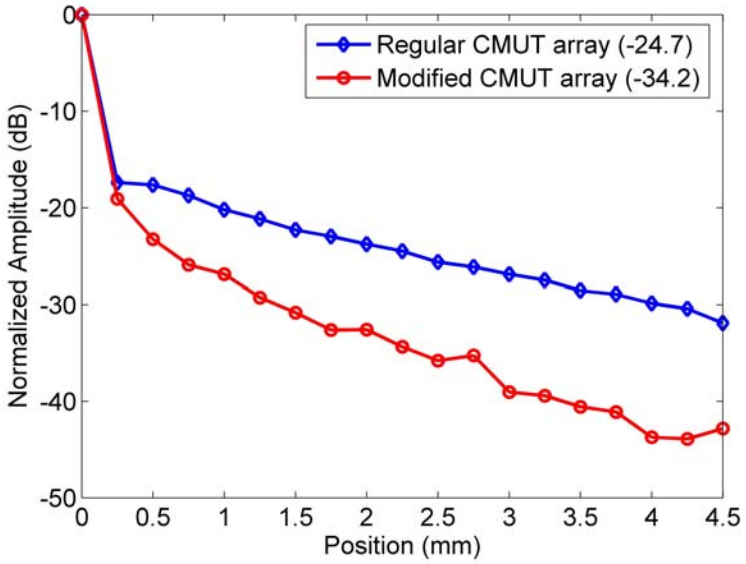


Reduced Crosstalk for the Modified CMUT

Pressure



Displacement



Crosstalk level is improved by approximately 10 dB for the modified CMUT array.

Conclusion

- Crosstalk in 1-D CMUT arrays is modeled using LS-DYNA in both conventional and collapsed modes.
- Finite element results are verified with the interferometer measurements.
- Dispersive guided mode is the main crosstalk mechanism.
- A powerful method based on the acoustic band gap is presented to reduce the crosstalk without loss of the pressure of the transmitter element.