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Determination of FDTR Lateral Resolution for Heterogeneously Integrated Micro Electronics

Rio Grande Symposium on Advanced Materials

Brenden Herkenhoff, Wyatt Hodges, Benjamin Treweek, Amun Jarzembski, Timothy Walsh, & Gregory Pickrell

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Background

- Thermomechanical simulation for interconnects in heterogeneously integrated (HI) microsystems is challenging, and thus design is challenging
- Several limitations
  - Lack of published knowledge on aging
  - Lack of advanced characterization techniques
  - Limited capabilities

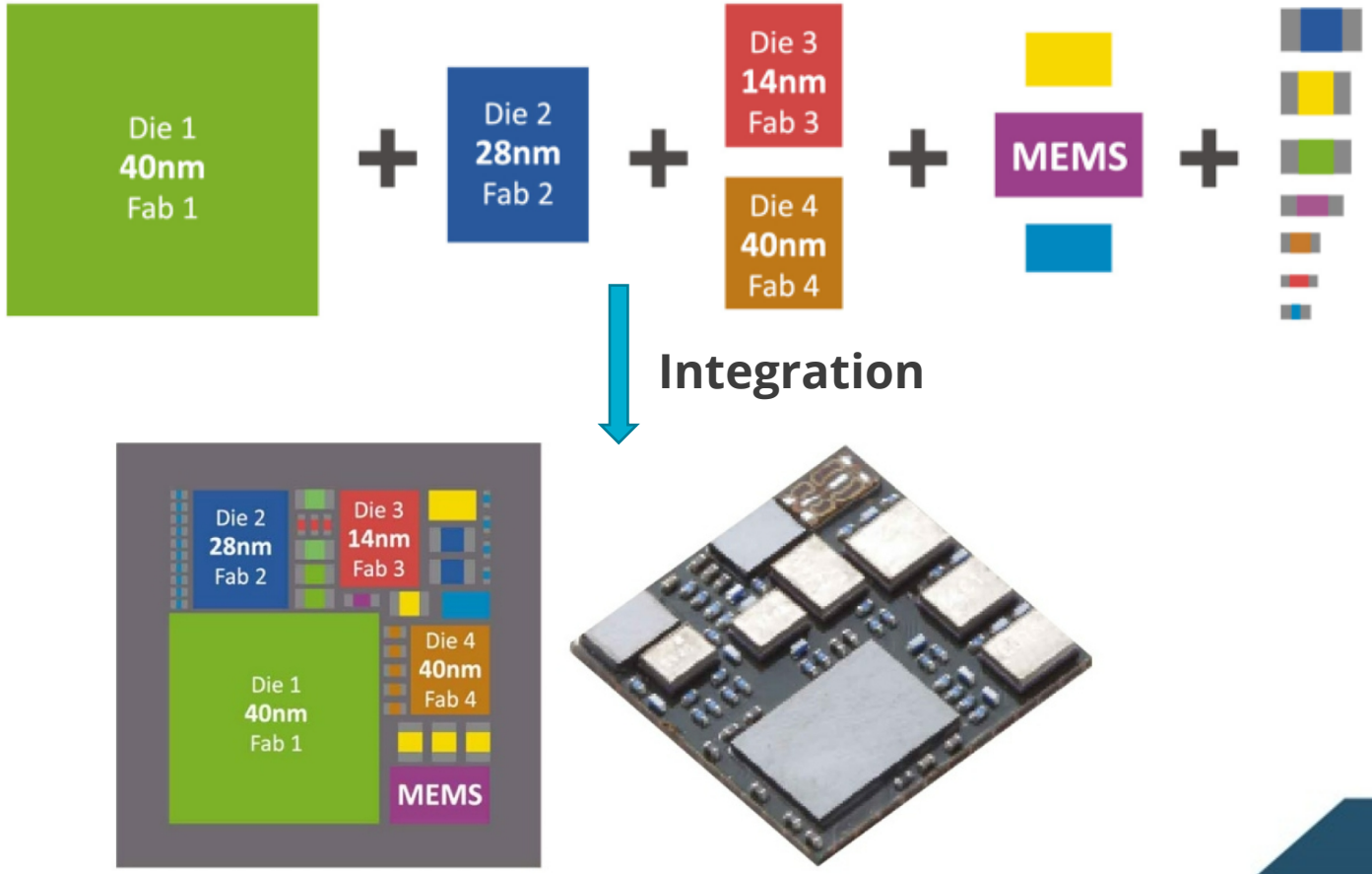
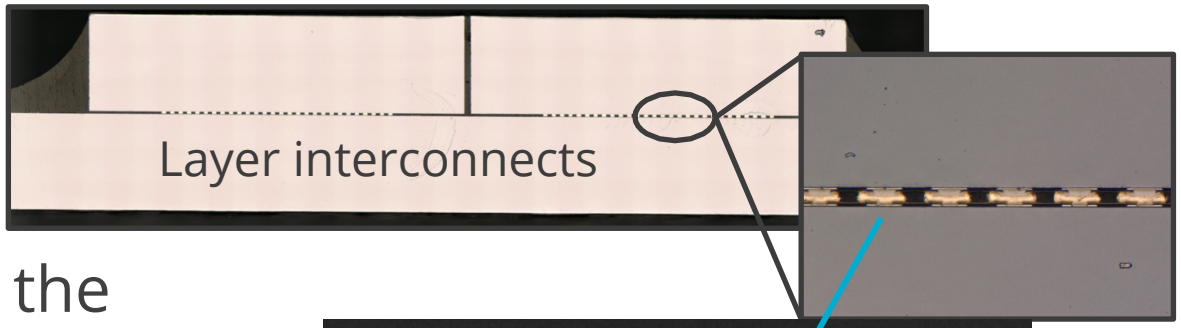
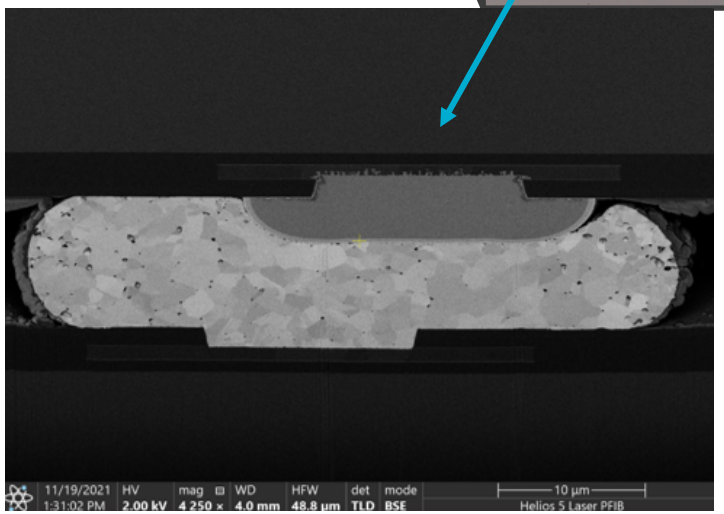


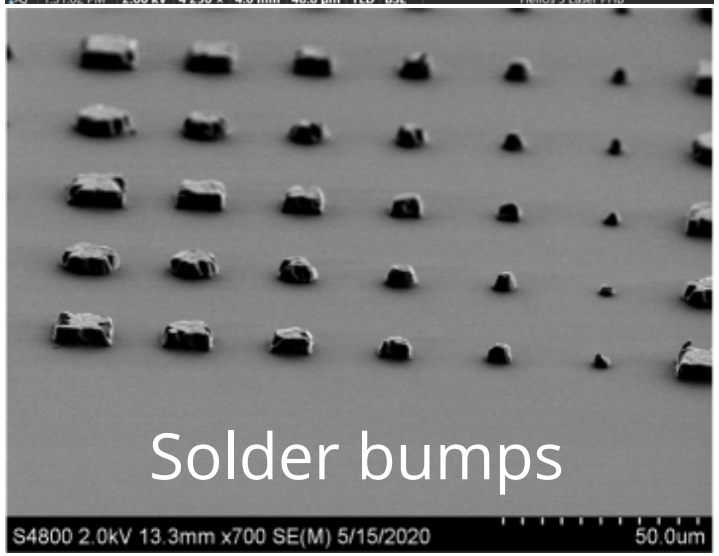
Image credit: https://ase.aseglobal.com/en/heterogeneous_integration

Background

- As manufacturing capability advances, the proliferation of HI systems will continue
  - Increased complexity
  - Subject to thermal and mechanical environmental stress
- Development of high precision diagnostic tools becomes increasingly important
- Previous work has shown thermal property measurements can be used to measure the interfacial properties
  - Frequency Domain Thermoreflectance (FDTR) provides an non contact non-destructive technique

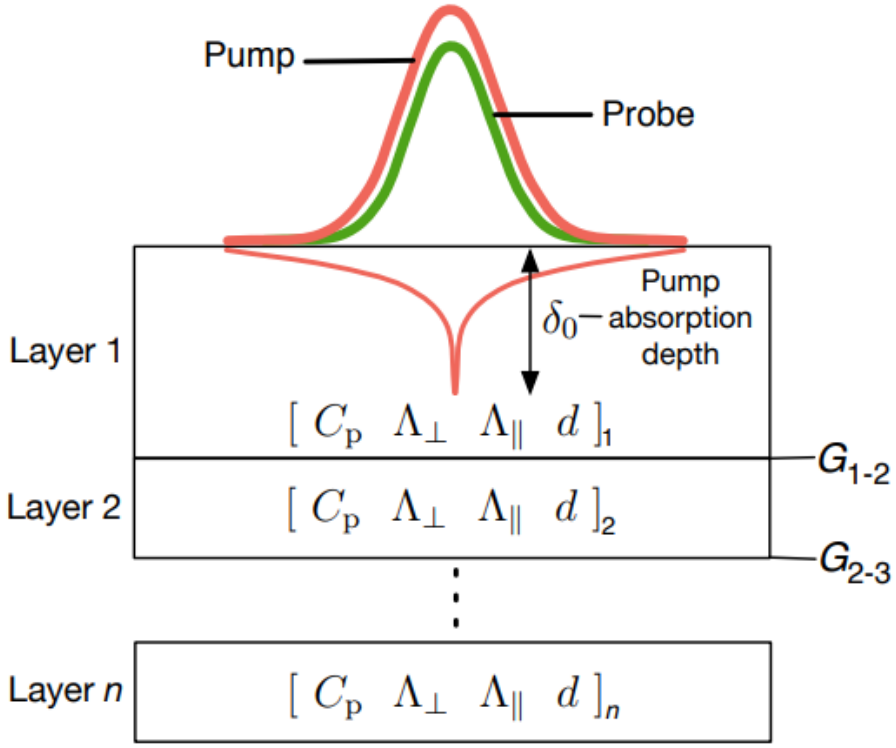






FDTR Overview

- Gaussian beam distribution of pump and probe
- Probe Signal detected by lock-in amplifier
  - Complex frequency response of experimental situation



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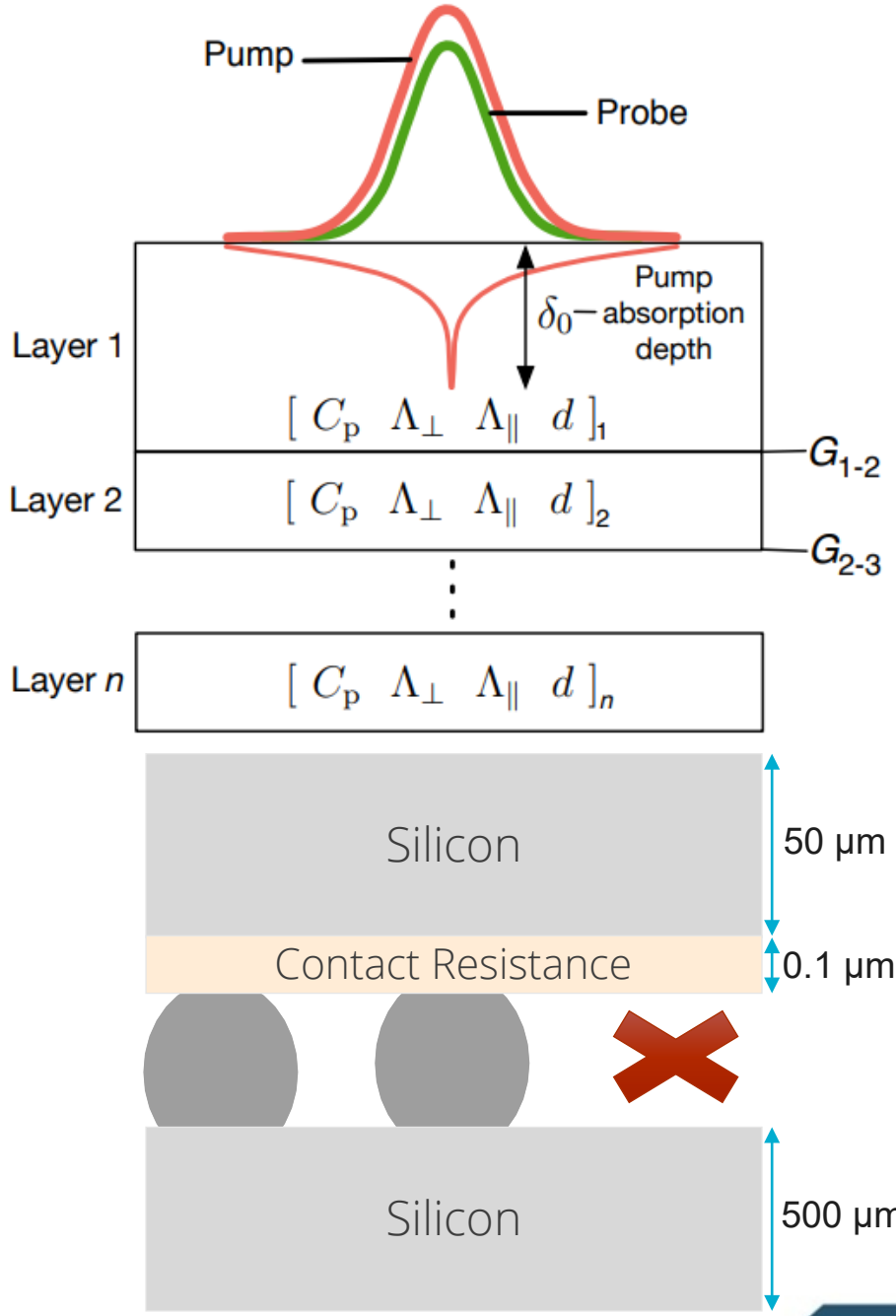

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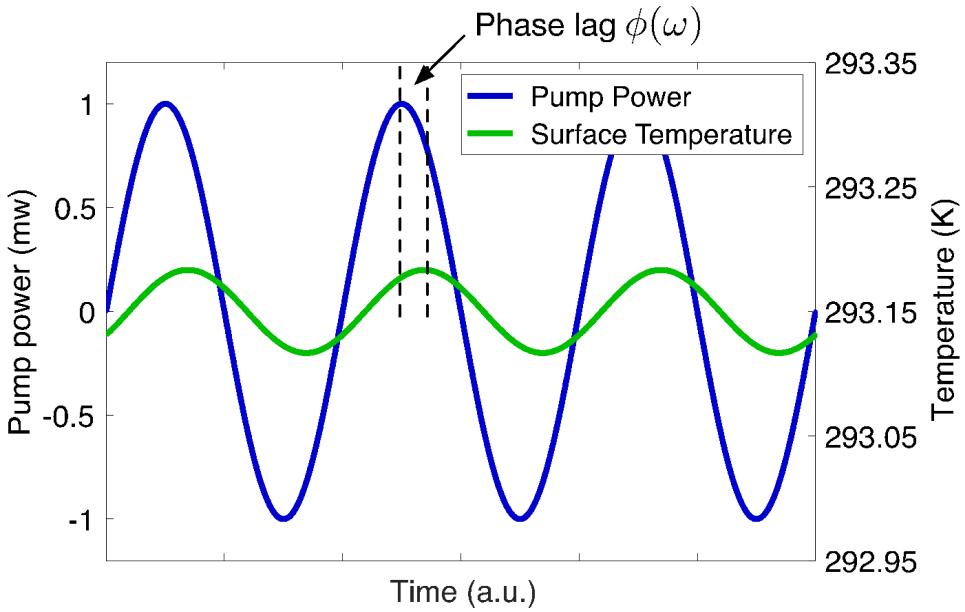

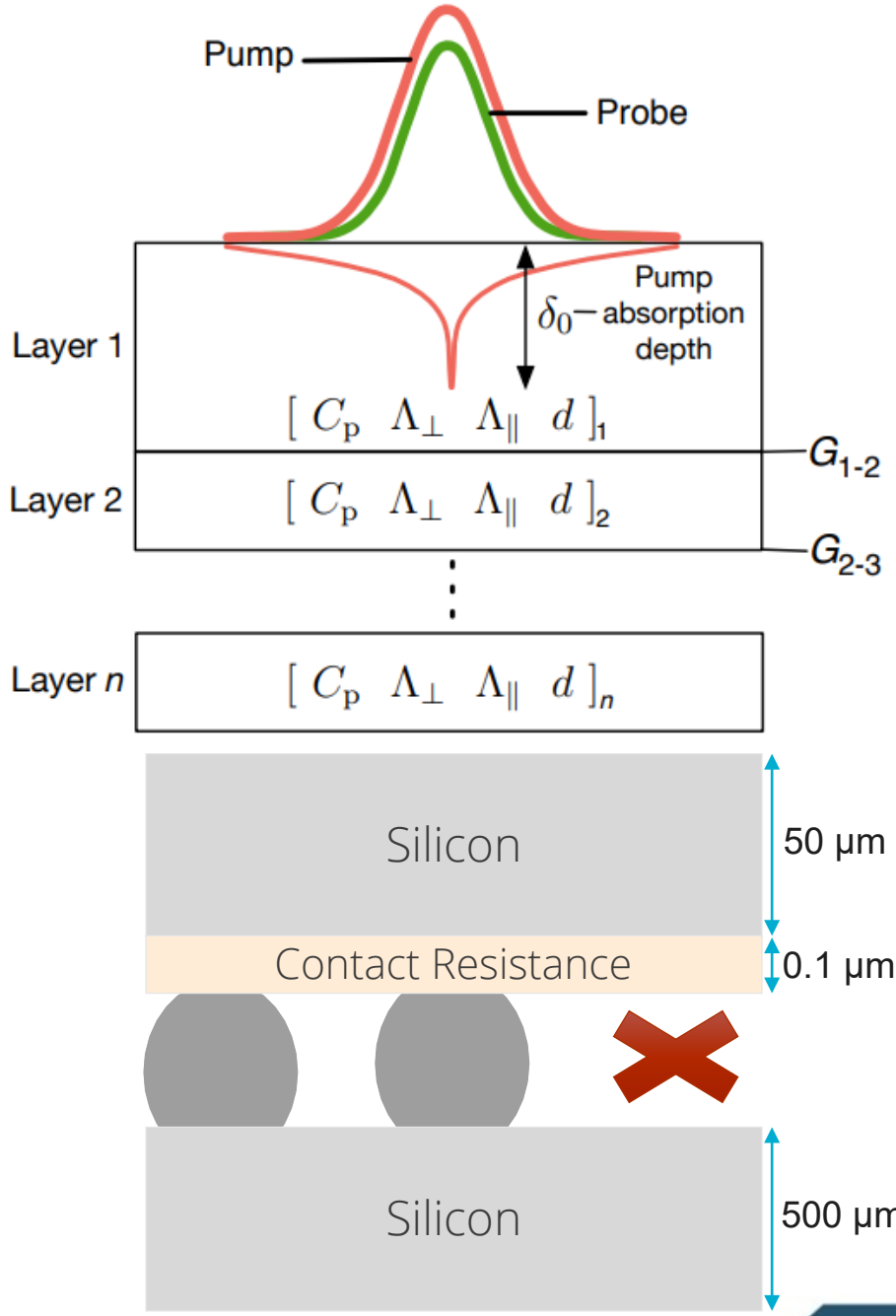

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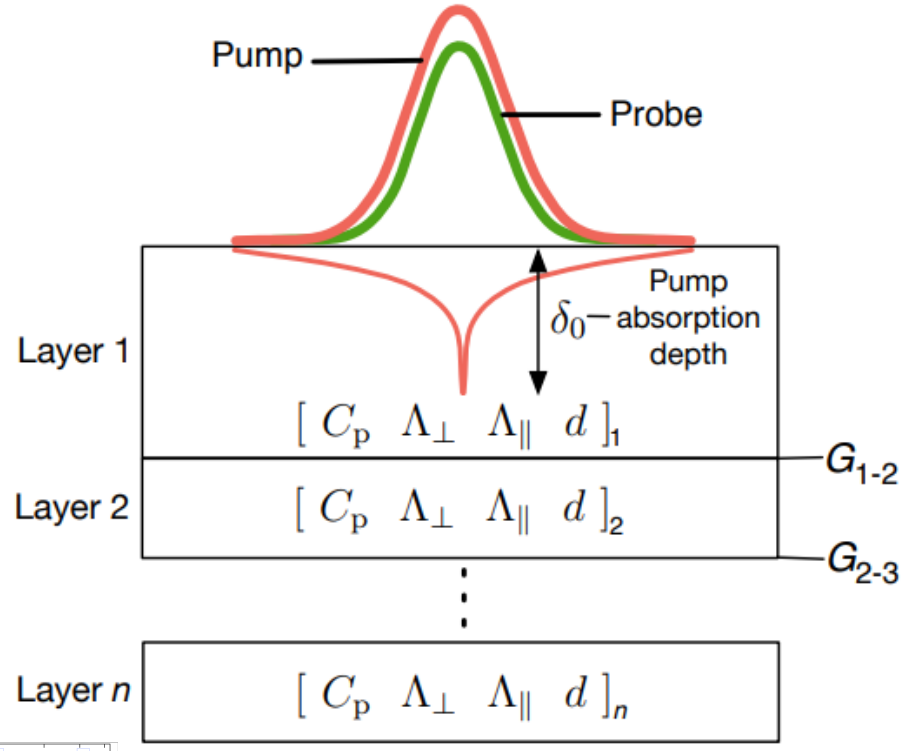
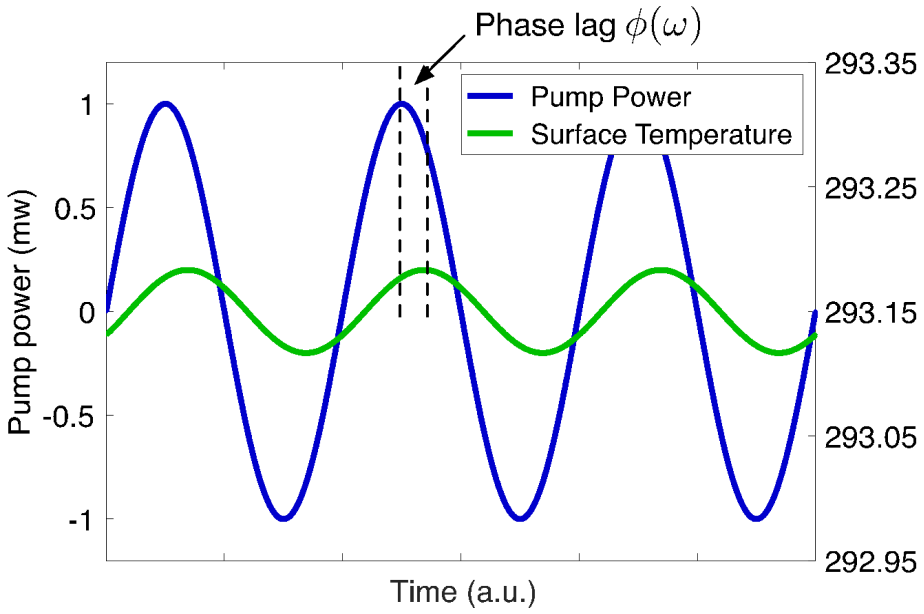
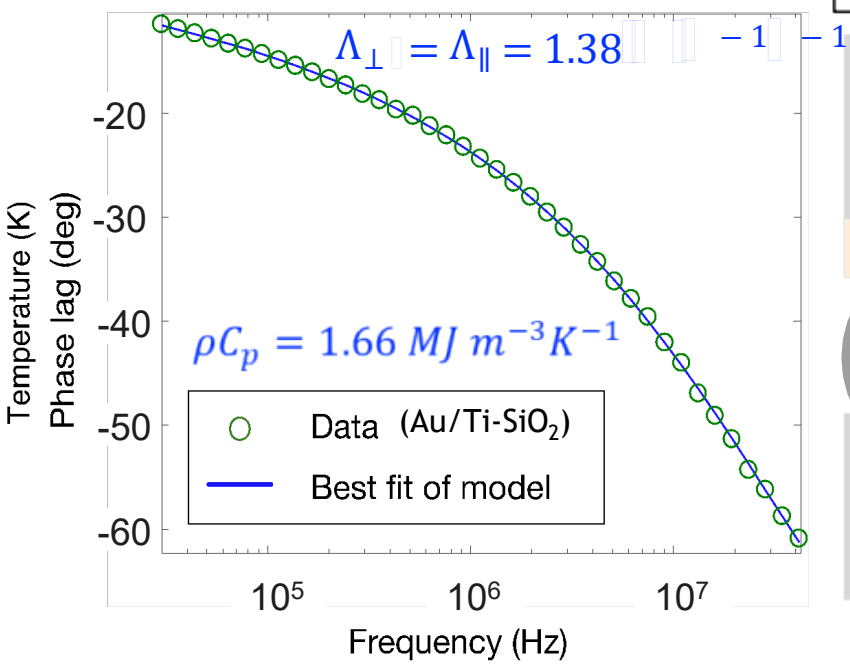
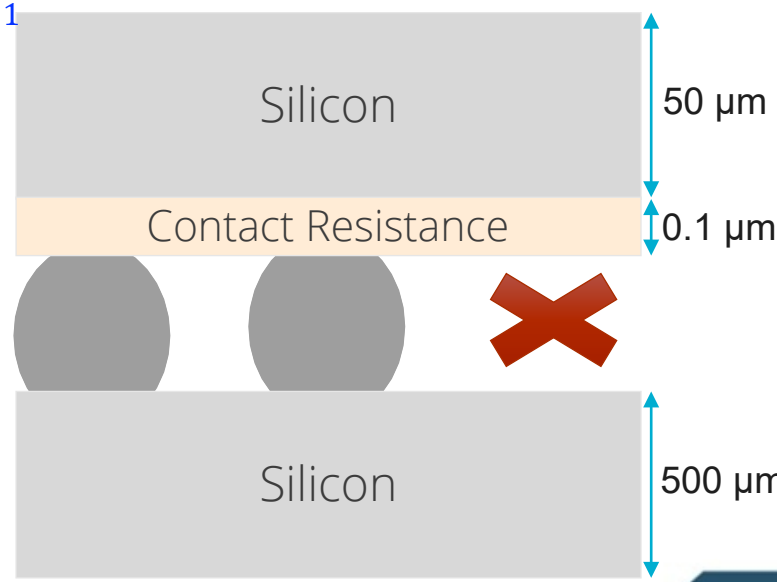


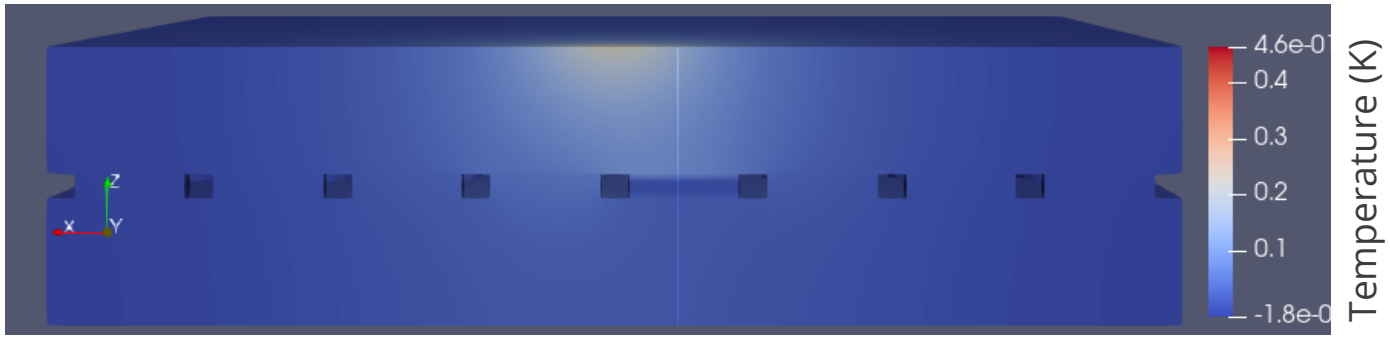




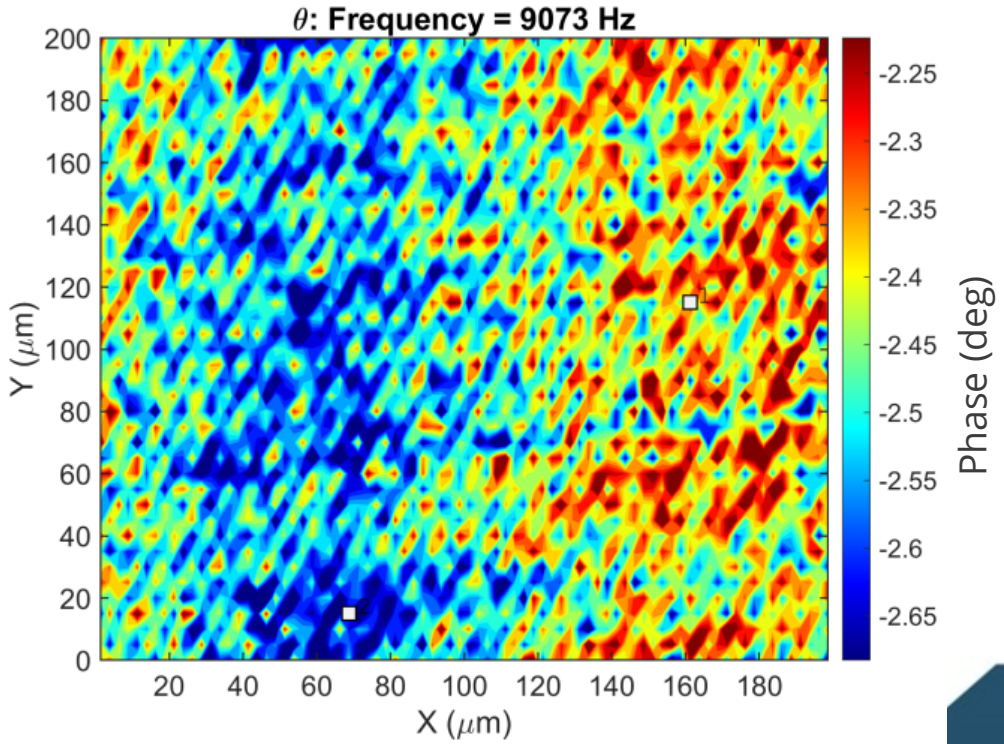


Goal of Current Work

- Model the limits of FDTR
  - Lateral resolution capability and depth variation for varying geometry
- Match simulations to corresponding experiments
- Viability of interconnects



Match simulation with experimental



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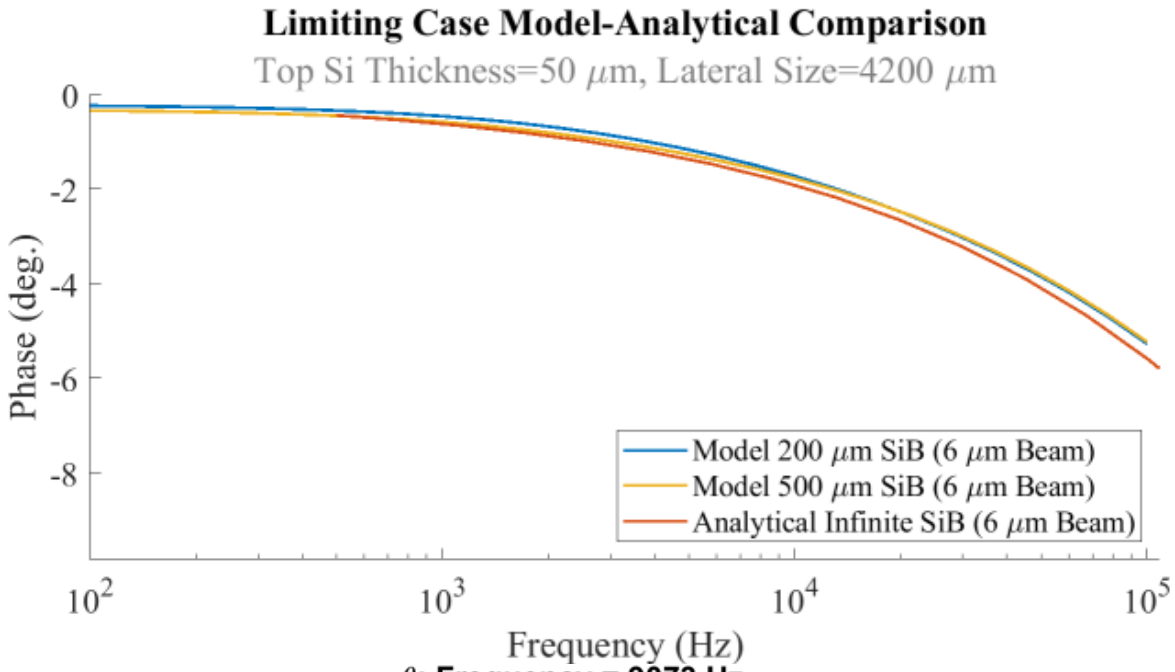

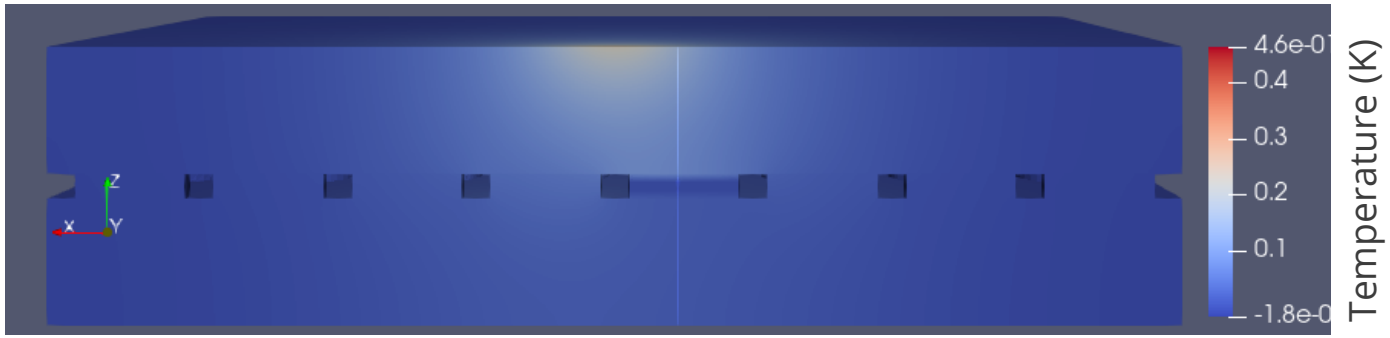

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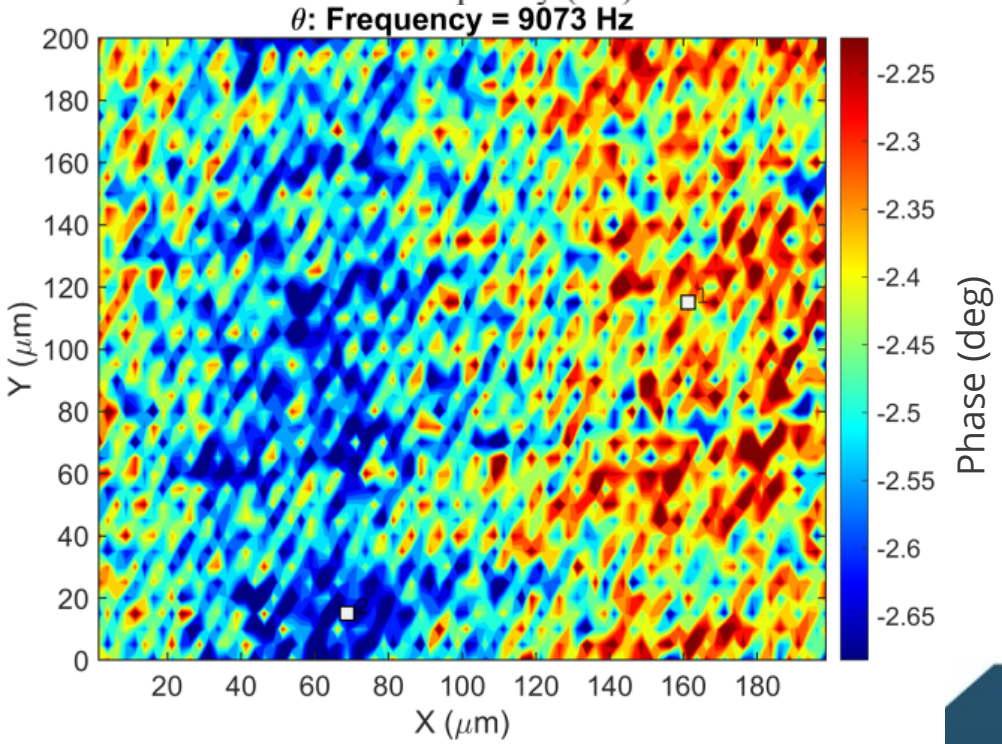
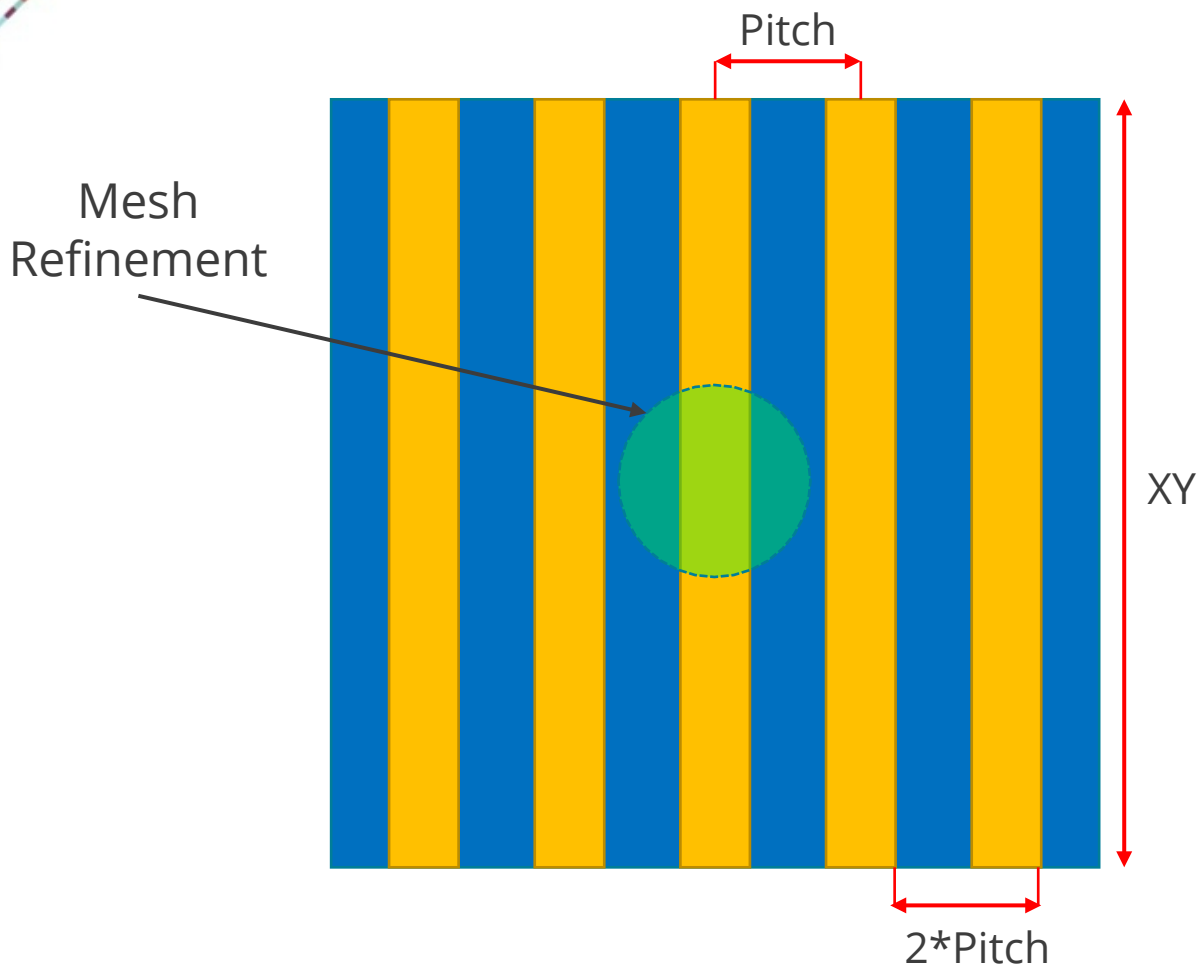
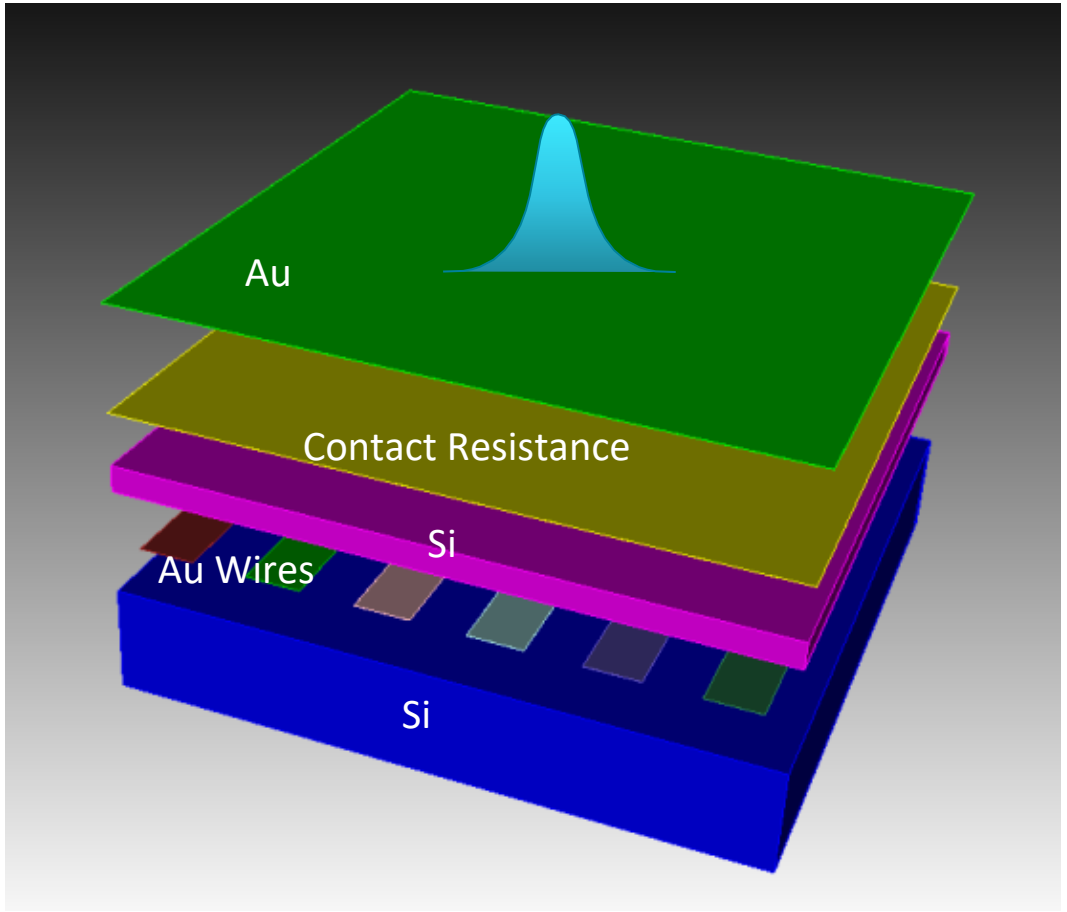
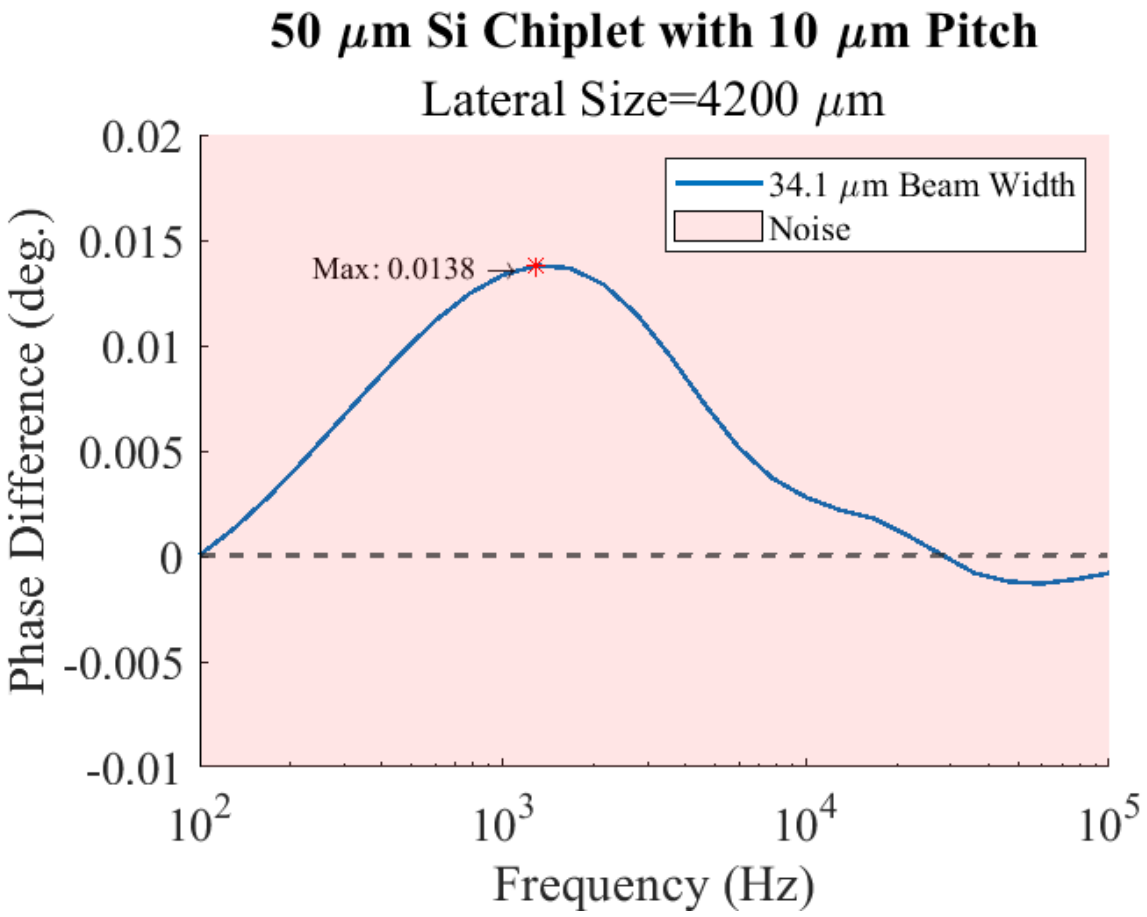


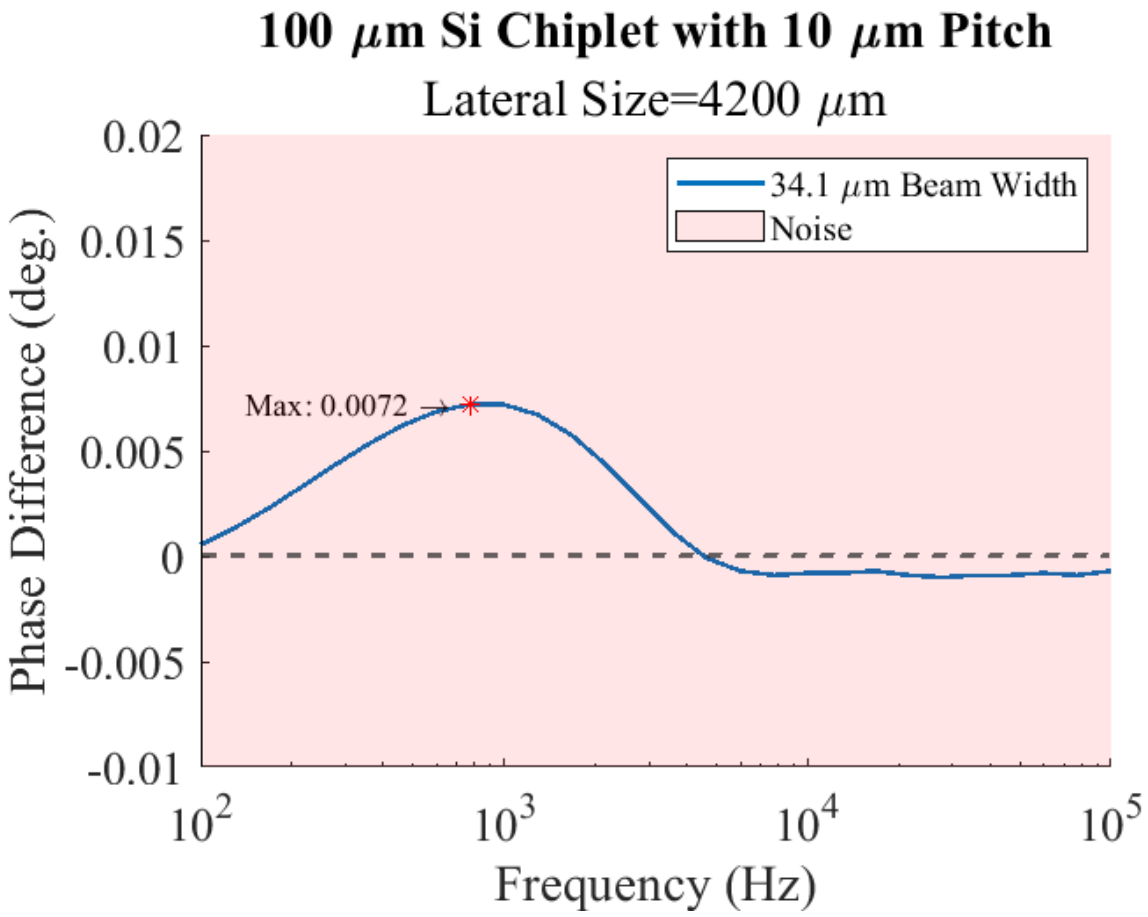
Geometry - Wires



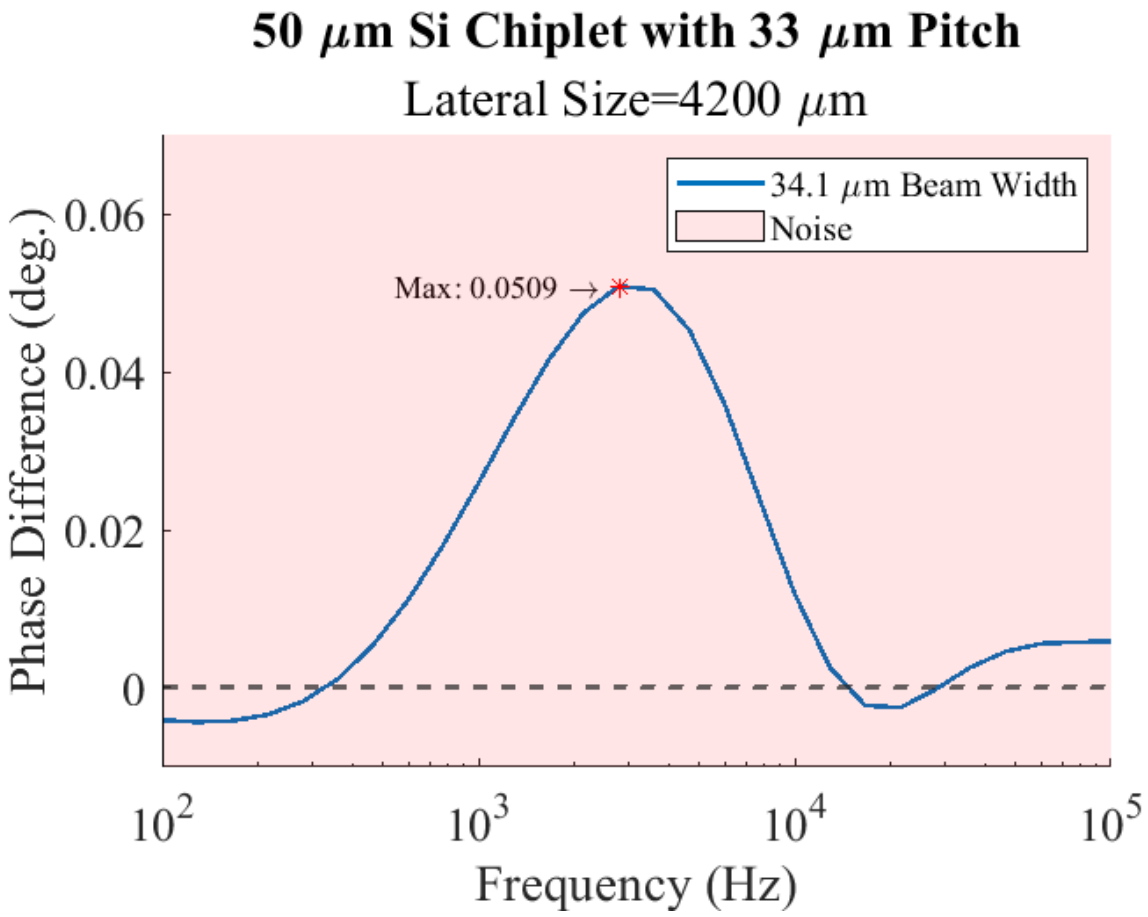


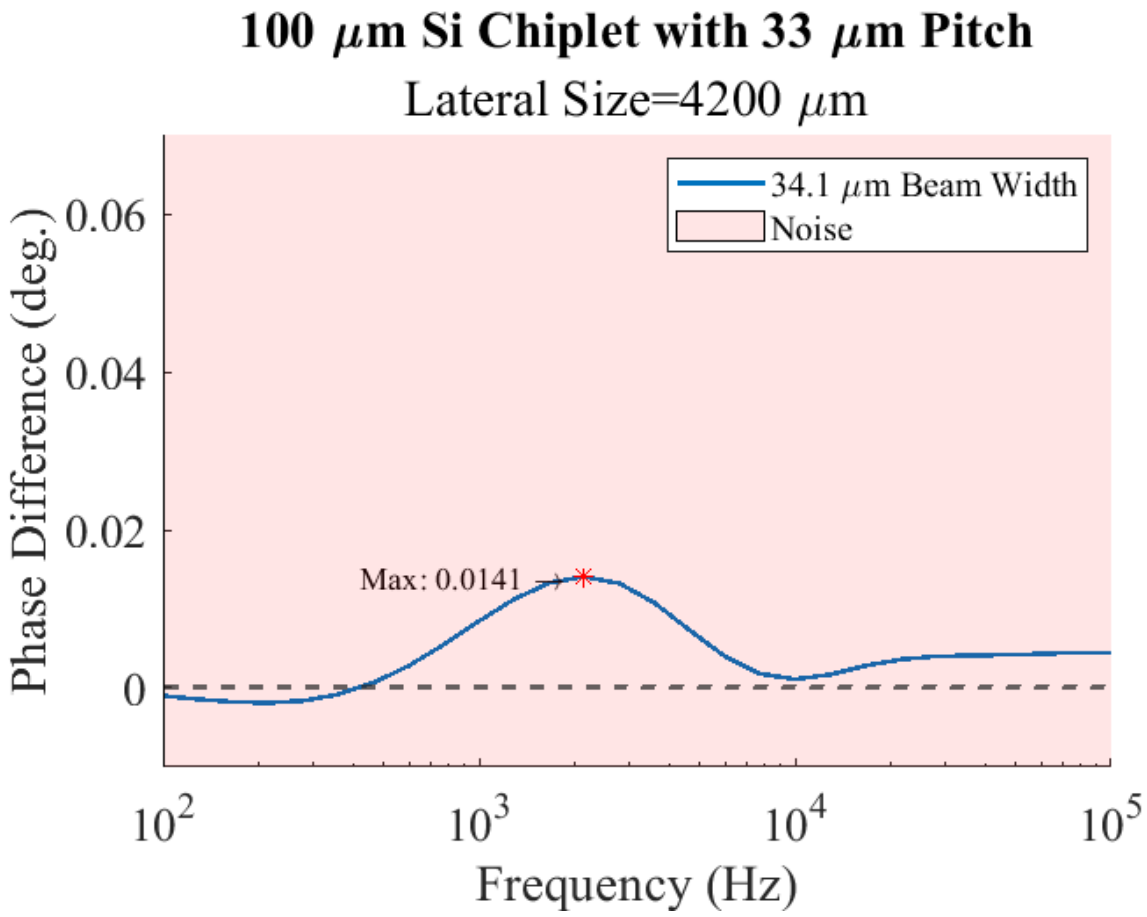
Simulation Results – 10 µm Pitch



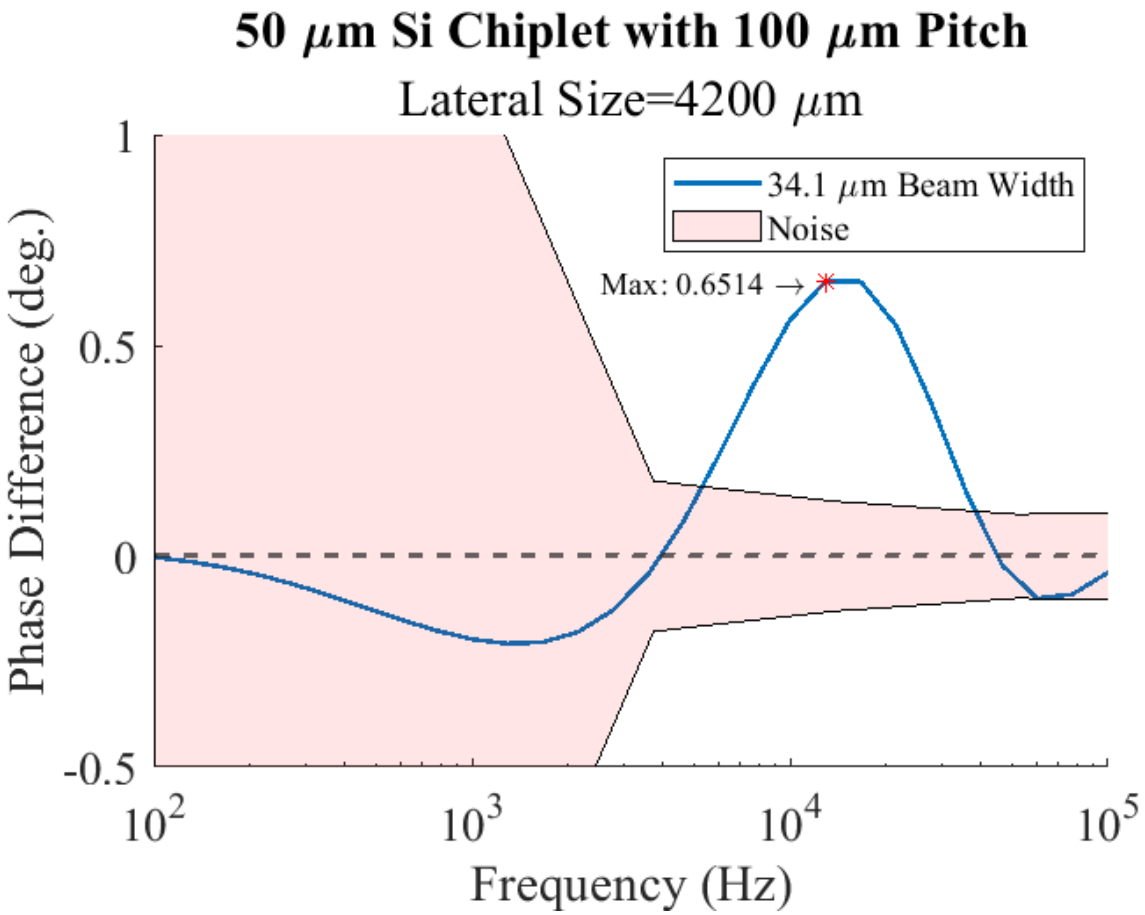


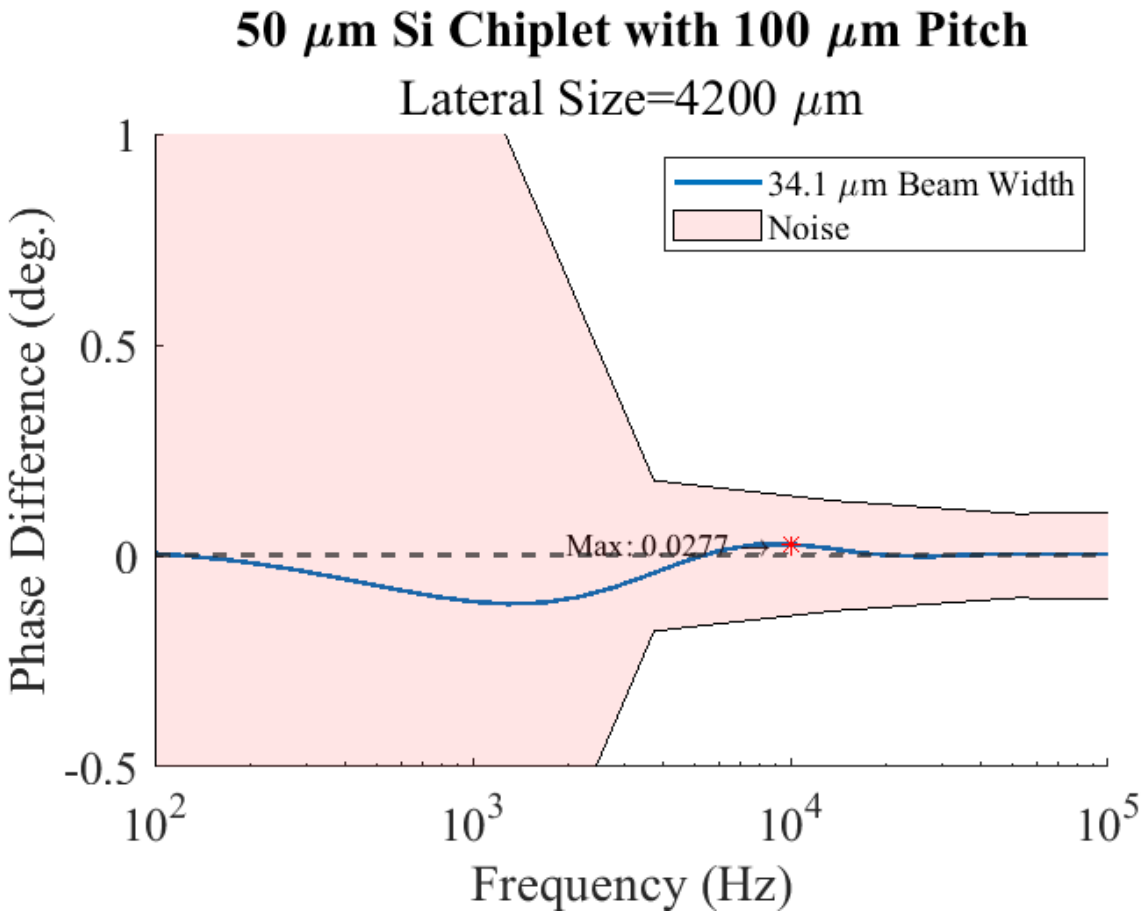
Simulation Results – 33 µm Pitch





Simulation Results – 100 µm Pitch





Conclusions and Team

- FDTR is on its way to non-destructive monitoring
- Discovered several errors in modelling that have been or are in the process of being resolved
- Noise floor comparison performed to show potential lateral resolution limits
- Ability to perform subsurface imaging on a micro-scale

FDTR/Optics
- Amun Jarzembski
- Anthony McDonald

Code development
- Ben Treweek
- Tim Walsh

Applications
- Greg Pickrell
- Matt Jordan
- Paul Clem
- Derek Wilke

Thermal modeling
- Wyatt Hodges
- Brenden Herkenhoff

LDRD LABORATORY DIRECTED RESEARCH & DEVELOPMENT
WHERE INNOVATION BEGINS