

Integrated Device to Simultaneously Characterize Thermal and Thermoelectric Properties

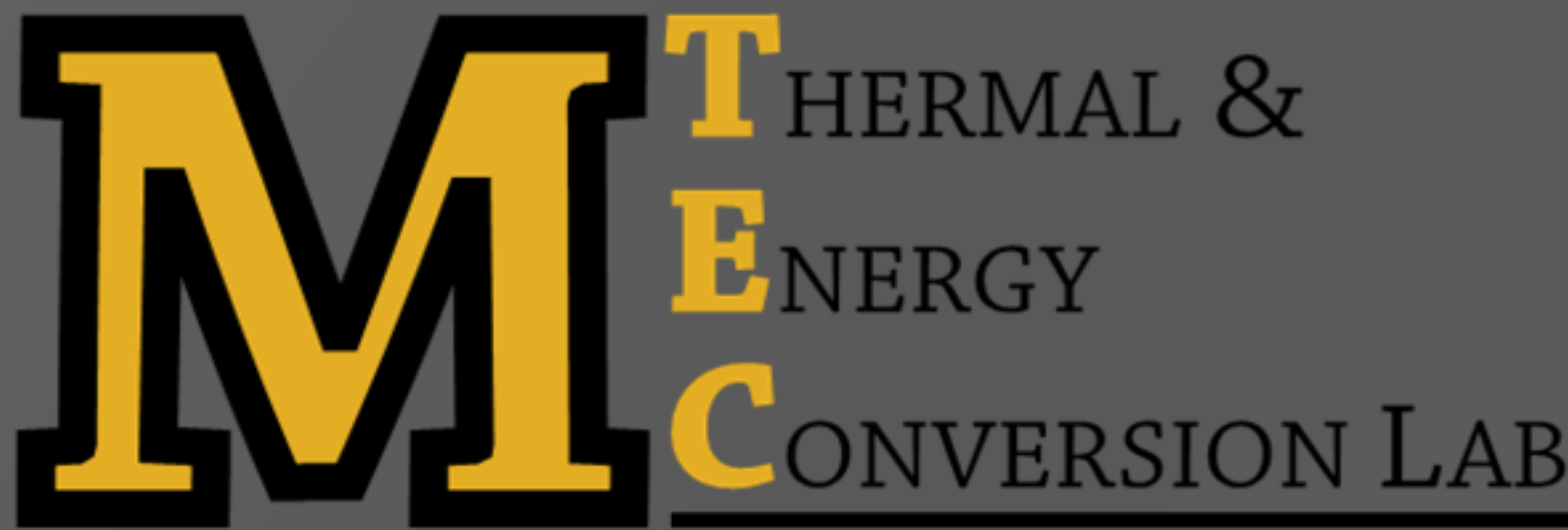
Collier Miers

PI: Amy Marconnet

engineering.purdue.edu/MTEC

Key Applications:

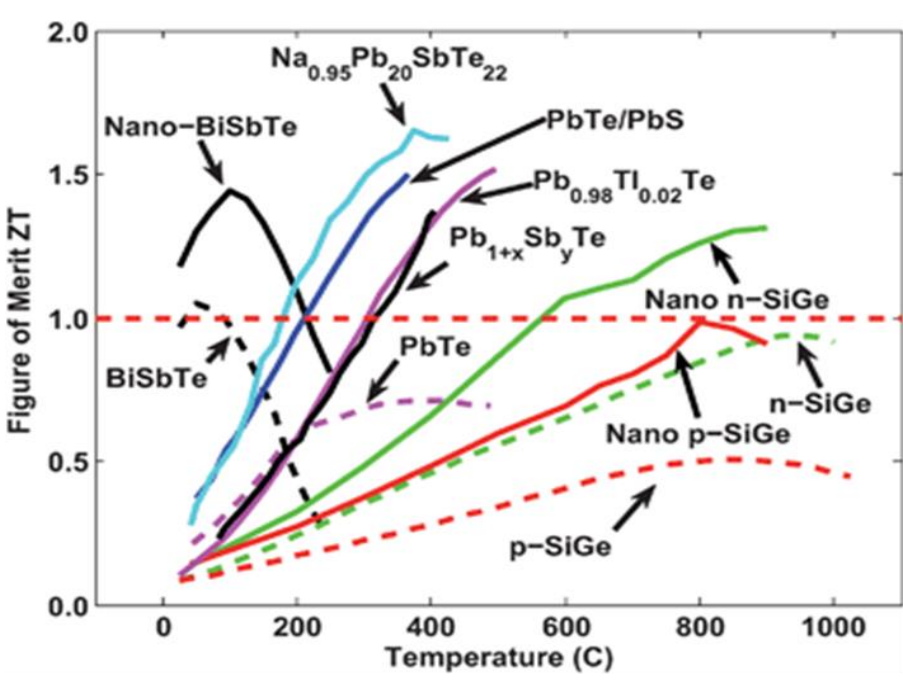
- Thermal Management and Electronics Cooling
- Thermoelectric Materials and Applications



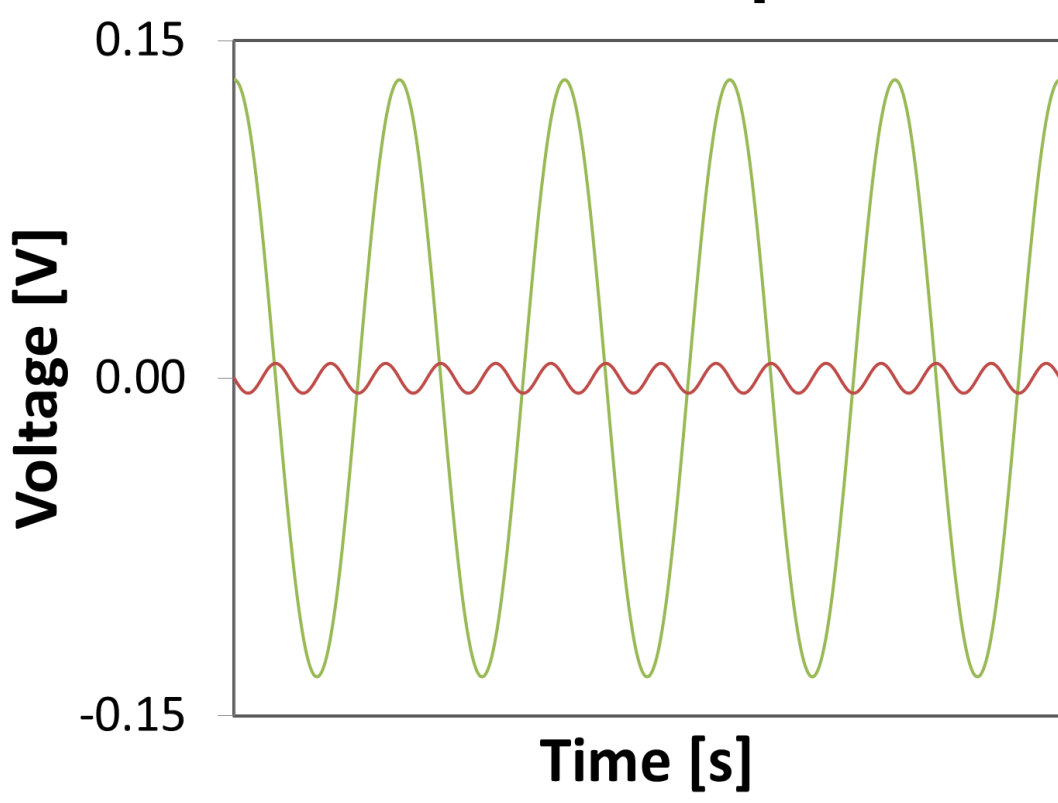
Measurement Structure, Optimization, and Fabrication

Figure of Merit

$$ZT = \frac{S^2 \sigma}{k} T$$



3ω Technique

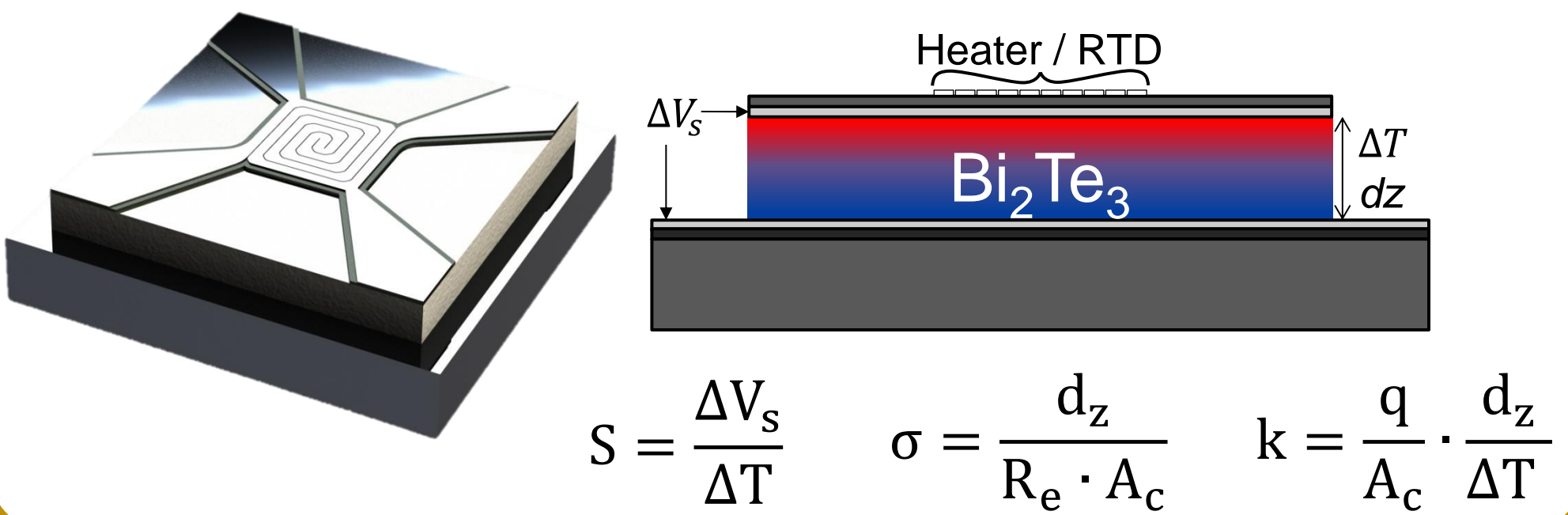


$$R_{2\omega} = R_o(1 + \alpha \Delta T_{2\omega})$$

$$V_{1\omega} = I_{1\omega} R_o$$

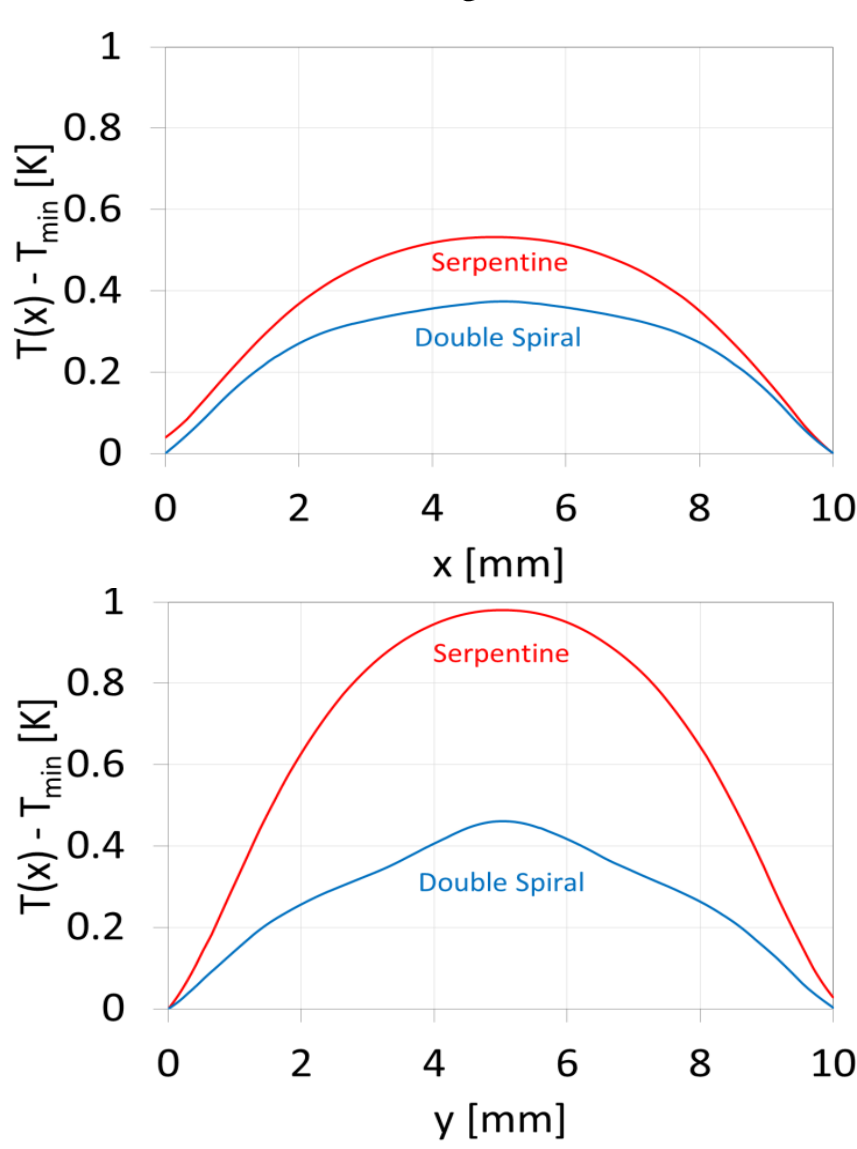
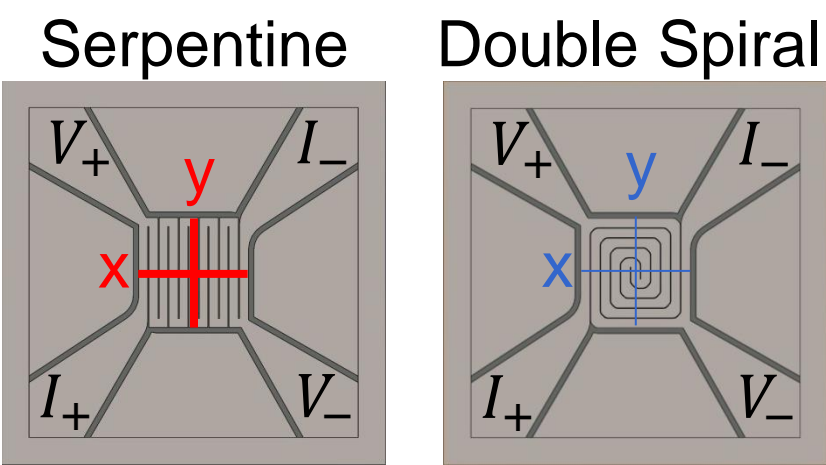
$$V_{3\omega} = I_{1\omega} R_{2\omega}$$

Simultaneous Measurement Structure



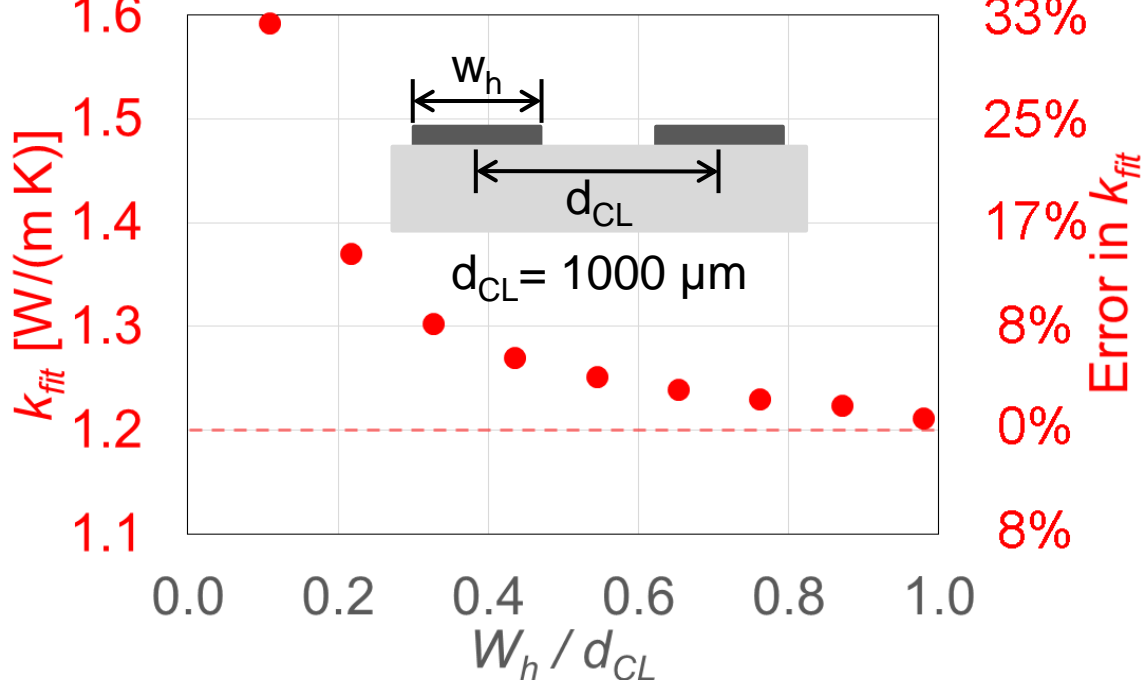
$$S = \frac{\Delta V_s}{\Delta T} \quad \sigma = \frac{d_z}{R_e \cdot A_c} \quad k = \frac{q}{A_c} \cdot \frac{d_z}{\Delta T}$$

Heater Uniformity



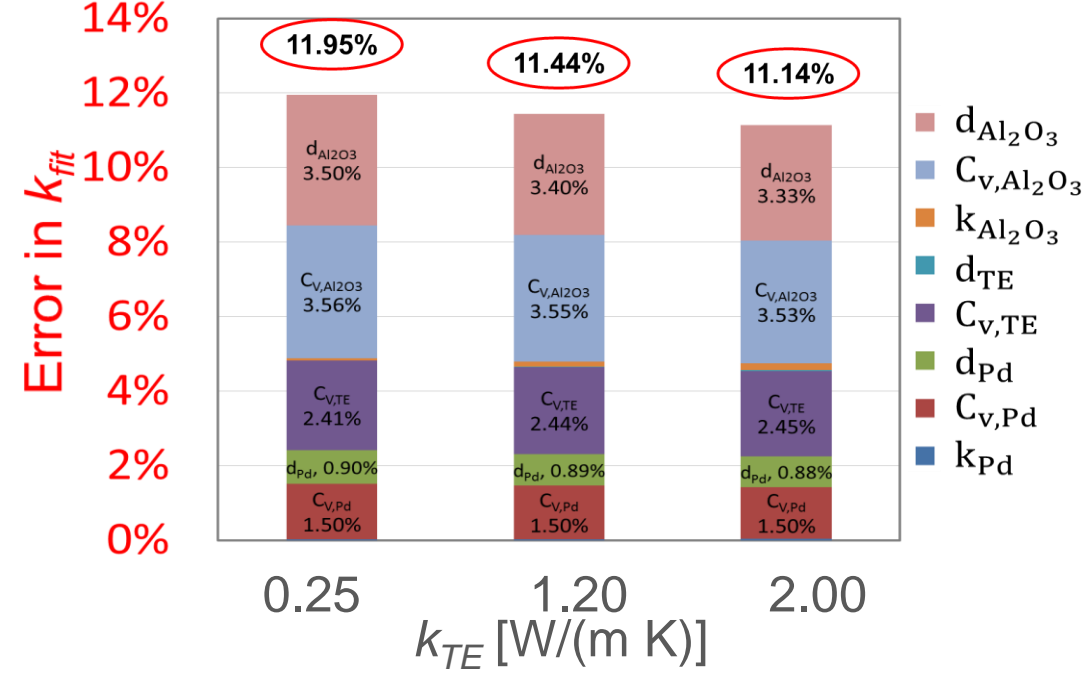
Palladium heater/RTD:
Geometry optimized for a uniform temperature distribution.

Heater Spacing

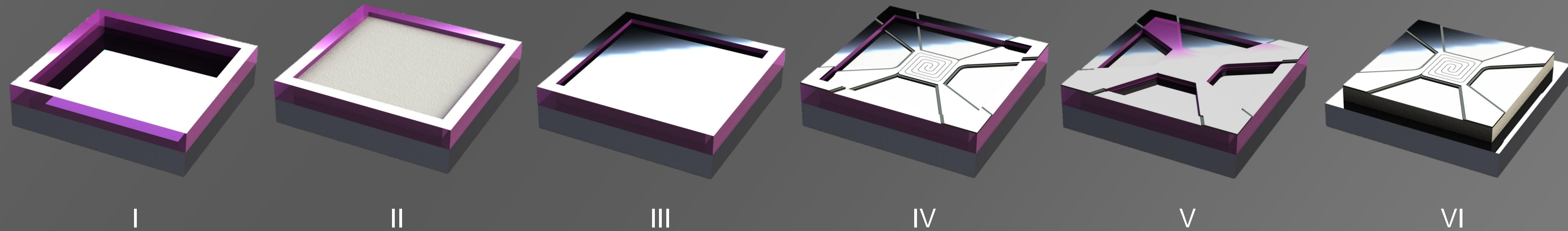


A sweep of heater line width to spacing ratio to investigate the impact on the accuracy of the measurement.

Tolerance Impact



Measurement structure parameters $\pm 5\%$ to show impact of tolerance variations and property uncertainty in the fabrication process.



Future Work

Goal: Control and optimization of nanostructure composition and geometry to improve understanding of trends in the thermal properties, allowing optimization for specific applications.

Modeling/Simulation:

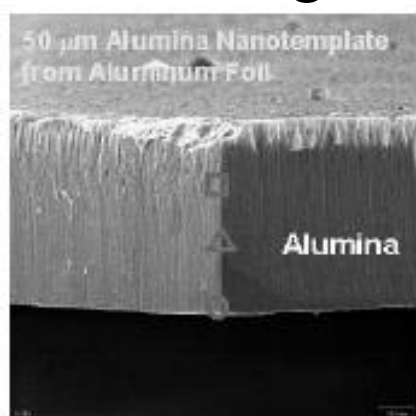
- Enhance current model by incorporating additional physics
 - Thermal losses
 - Electric effects
- New model to investigate the impact of nanostructuring on performance of thermoelectric materials

Experimental:

- Model verification and validation
- System benchmarking with Bi_2Te_3
- Characterization of novel materials
 - Polymers
 - Nanostructured Materials
- High temperature testing
- Device scale testing

Novel Materials:

- Thermally tunable materials through control of nanostructure geometry
- Scalable thermoelectric materials for waste heat recovery
- Lightweight & thermally conductive metallic structures for heat dissipation
- Surfaces for enhanced boiling



Myung, ECS 2003.