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IMPROVEMENT OF A STEADY STATE METHOD OF THERMAL INTERFACE MATERIAL CHARACTERIZATION BY USE OF A THREE DIMENSIONAL FEA SIMULATION IN COMSOL MULTIPHYSICS

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PROBLEM STATEMENT

- ✓ Problem Statement
- Background
- Methodology
- COMSOL Model
- Mesh
- Results
- Concluding Remarks

- The Lab of Applied Multiphase Thermal Engineering at Dalhousie University has a contract with Raytheon to work on the characterization of thermal interface materials (TIMs).
- The first step in the project was to build and test a steady state characterization device.
- The goal of the work presented here was to create an FEA simulation of that test device which could be used to improve the accuracy of the experiment.

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- What are Thermal Interface Materials?
- Materials which are designed to increase the thermal conductance of an interface between two surfaces.
- A common application is to reduce resistance of the conduction path from a microchip to a heat sink.

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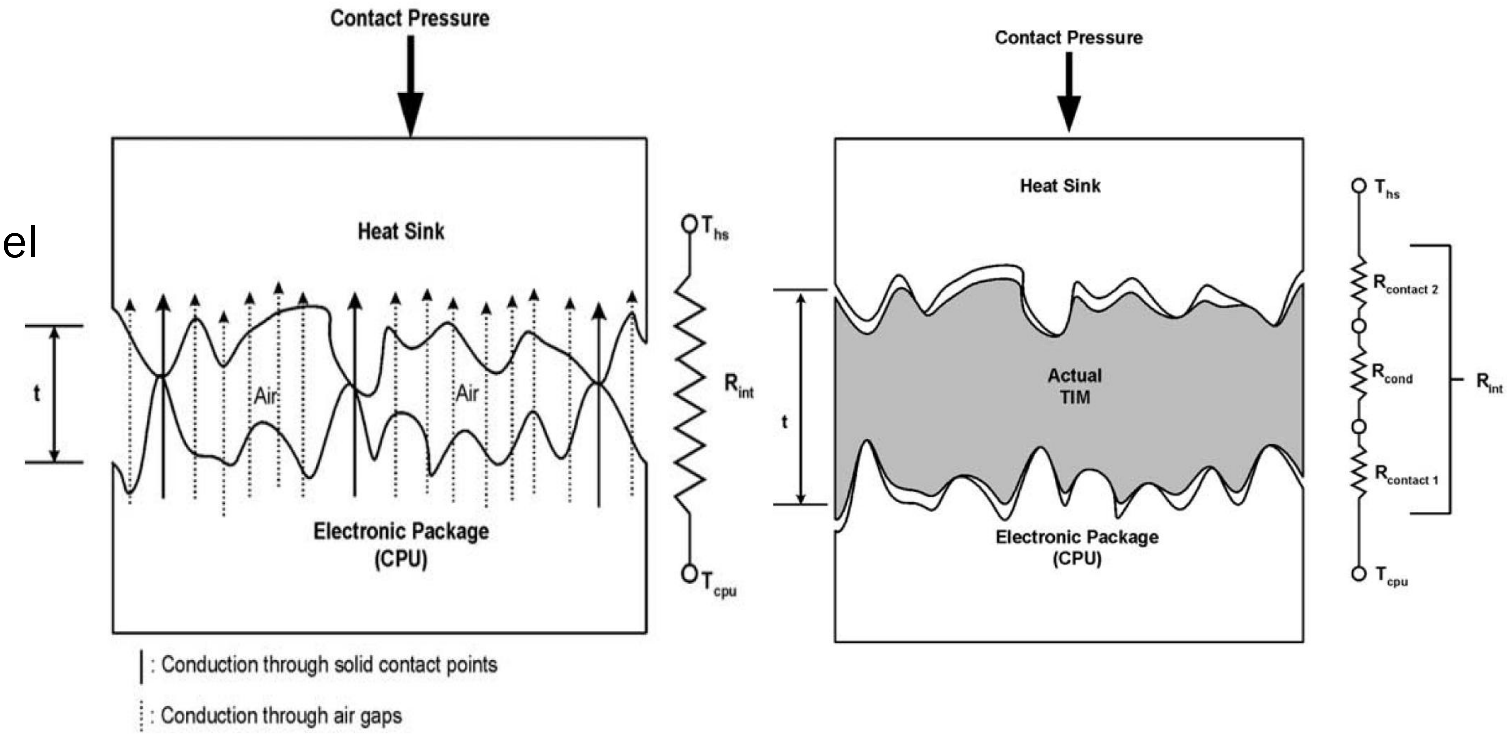

Illustration of contact resistance [1]

Lab of Applied MultiPhase Thermal Engineering

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- The performance of a TIM is a function of:
  - Effective thermal conductivity
  - Ability to conform to surface features
  - Thickness of the TIM layer
- It is not possible to characterize the performance of a TIM with a single property such as bulk thermal conductivity.
- Roughness and surface flatness are important parameters
- Performance will vary with both clamping pressure and TIM temperature
- We must measure its performance while it is in an interface.

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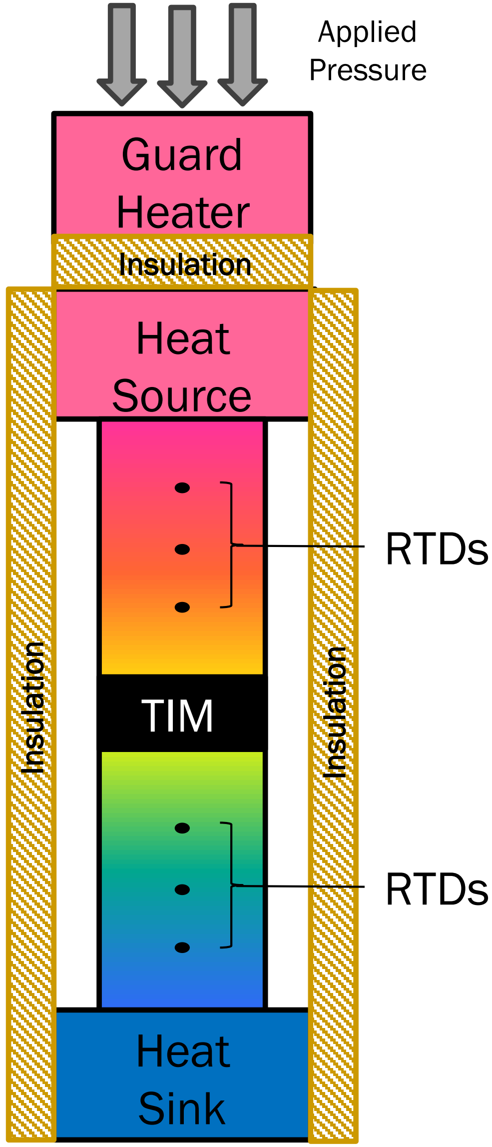

- An apparatus was designed to allow for steady state testing
- Steady state testing was based on the ASTM standard includes a guard heater, insulating sheath six RTD temperature sensors.
- The goal of the steady state test is to setup a one dimensional heat flow through the TIM sample

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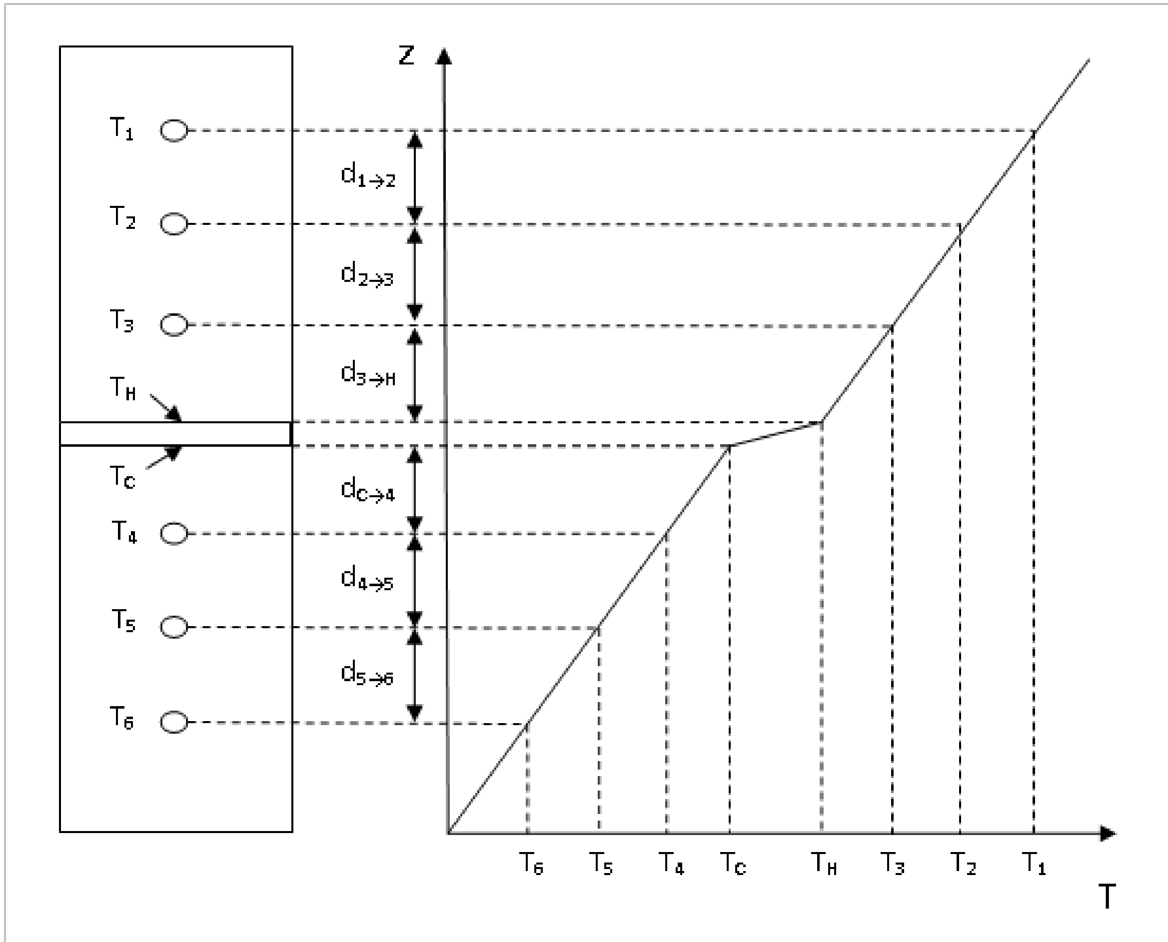

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$$\theta = QA^{-1}(T_H - T_C)^{-1}$$

$$\Delta T_{H\rightarrow C} = \Delta T_{3\rightarrow 4} - d_{3\rightarrow H}\left(\frac{dT}{dz}\right)_{hot} - d_{C\rightarrow 4}\left(\frac{dT}{dz}\right)_{cold}$$

$$\left(\frac{dT}{dz}\right)_{hot} = \frac{\Delta T_{1\rightarrow 3}}{d_{1\rightarrow 3}} \qquad \left(\frac{dT}{dz}\right)_{cold} = \frac{\Delta T_{4\rightarrow 5}}{d_{4\rightarrow 5}}$$

$$Q = kA\left[\frac{\left(\frac{dT}{dz}\right)_{hot} + \left(\frac{dT}{dz}\right)_{cold}}{2}\right]$$

$$\theta = \left[\frac{k}{2}\left(\left(\frac{dT}{dz}\right)_{hot} + \left(\frac{dT}{dz}\right)_{cold}\right)\right]\left[\Delta T_{3\rightarrow 4} - d_{3\rightarrow H}\left(\frac{dT}{dz}\right)_{hot} - d_{C\rightarrow 4}\left(\frac{dT}{dz}\right)_{cold}\right]^{-1}$$

θ = Thermal Conductance
Q= Heat Flow
k= Thermal conductivity of the meter bar
A=Cross sectional area of the meter bar

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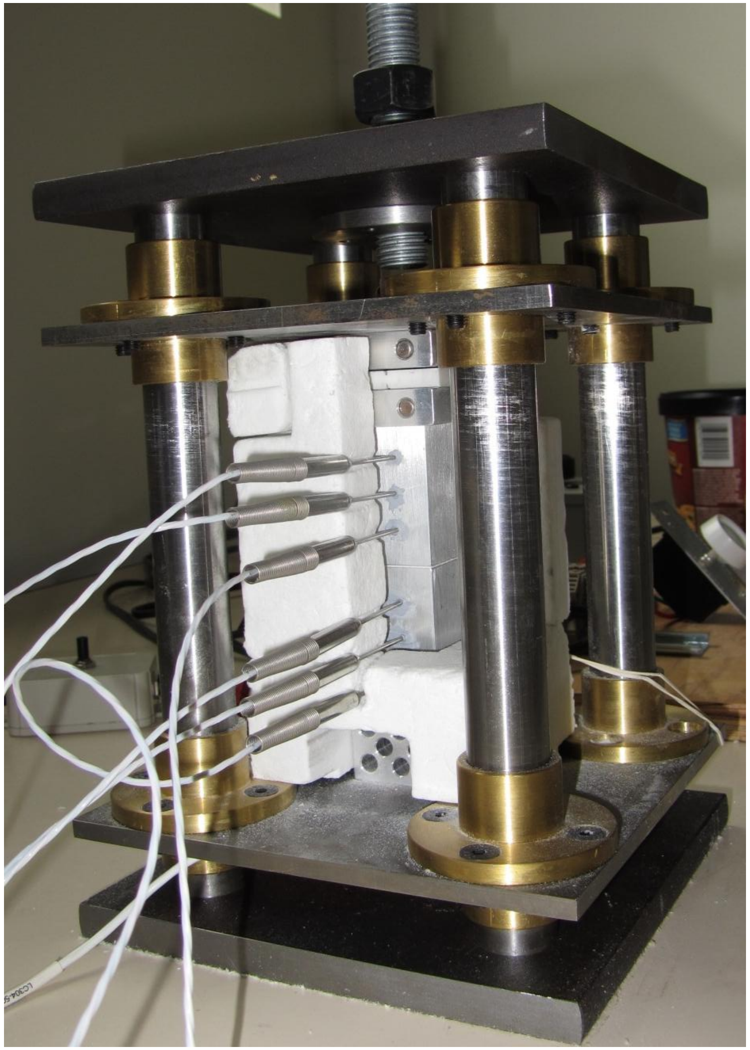

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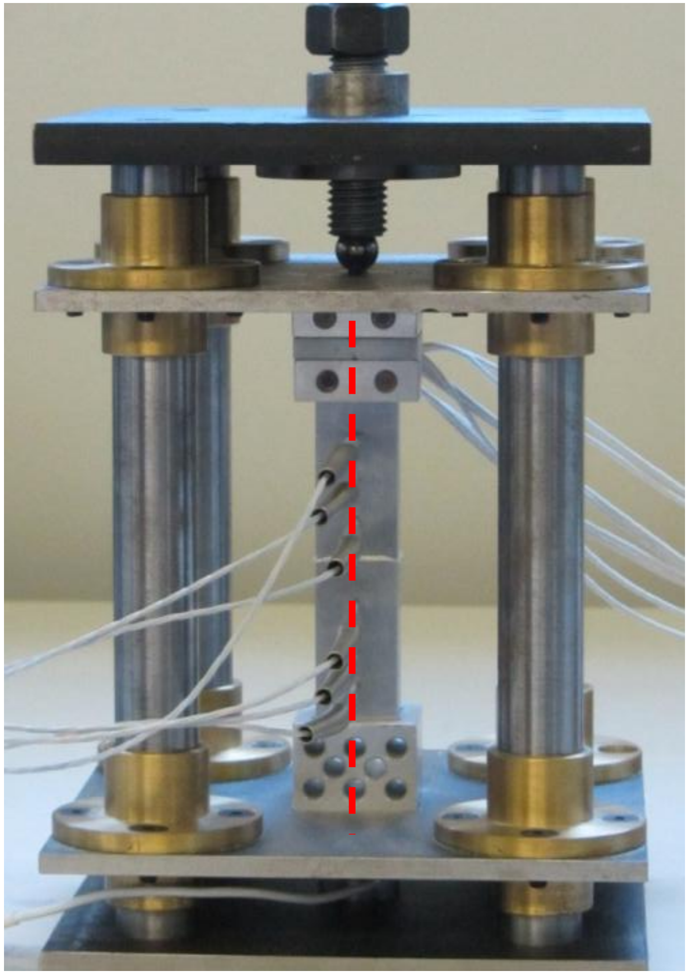

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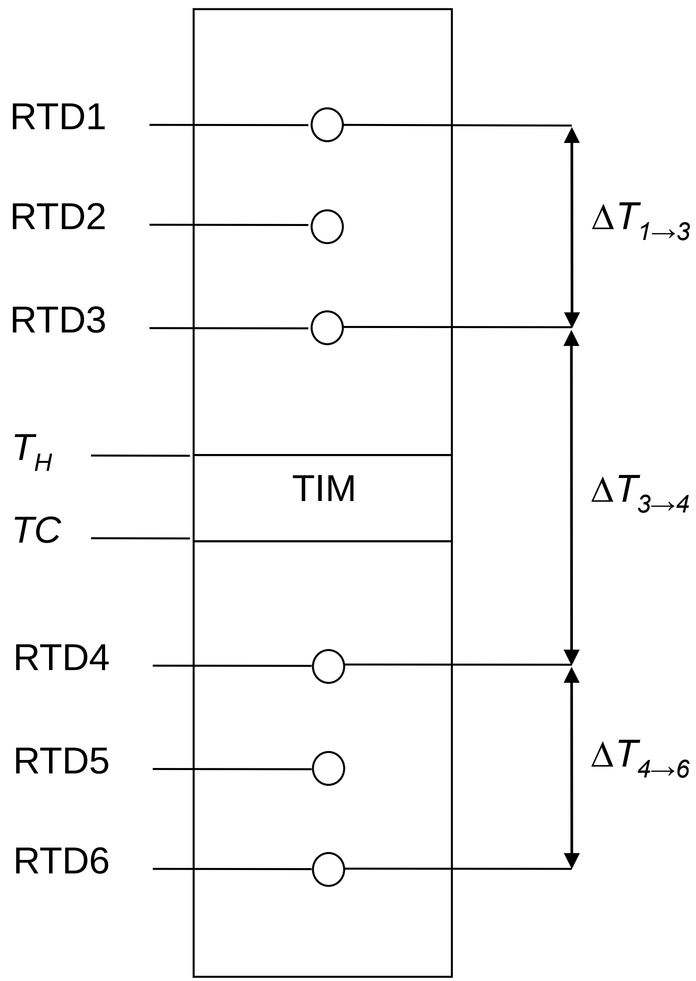

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Material	Density (kg/m^3)	Thermal Conductivity (W/mK)	Specific Heat (J/kgK)
Al 6061 T6	2700	167	900
Superwool 607	335	0.06	0.243
Macor	2520	1.46	790
Air	COMSOL Materials Database		

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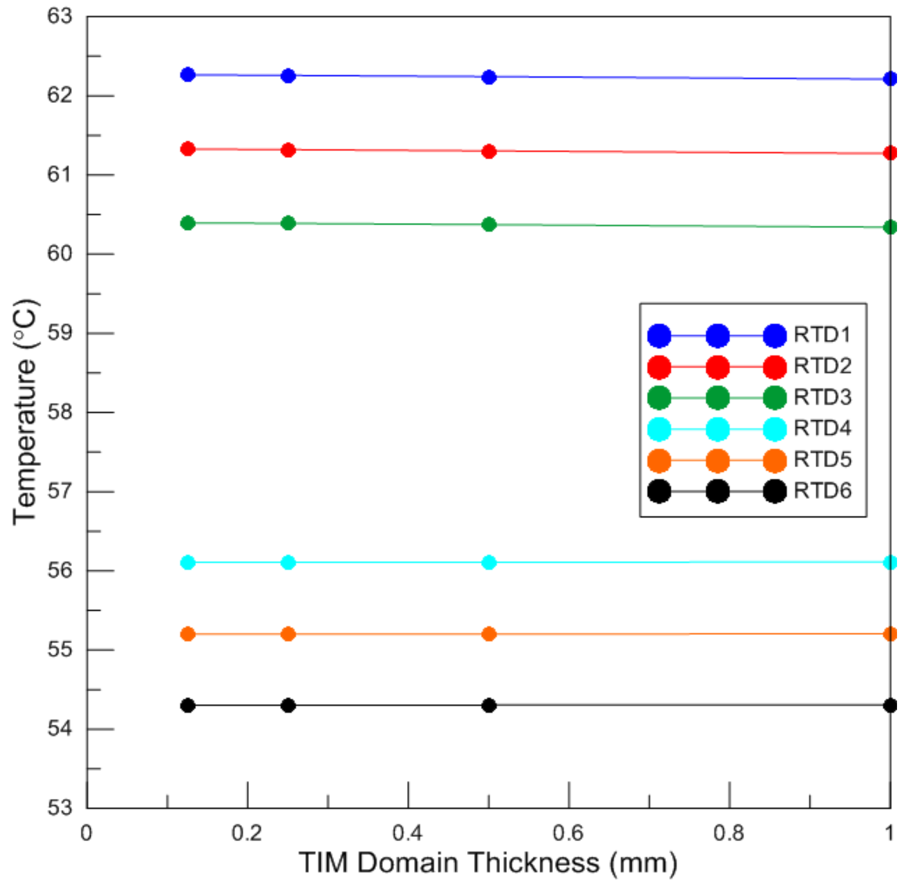
$$K_{TIMdomain} = d_{TIMdomain}\,\theta$$



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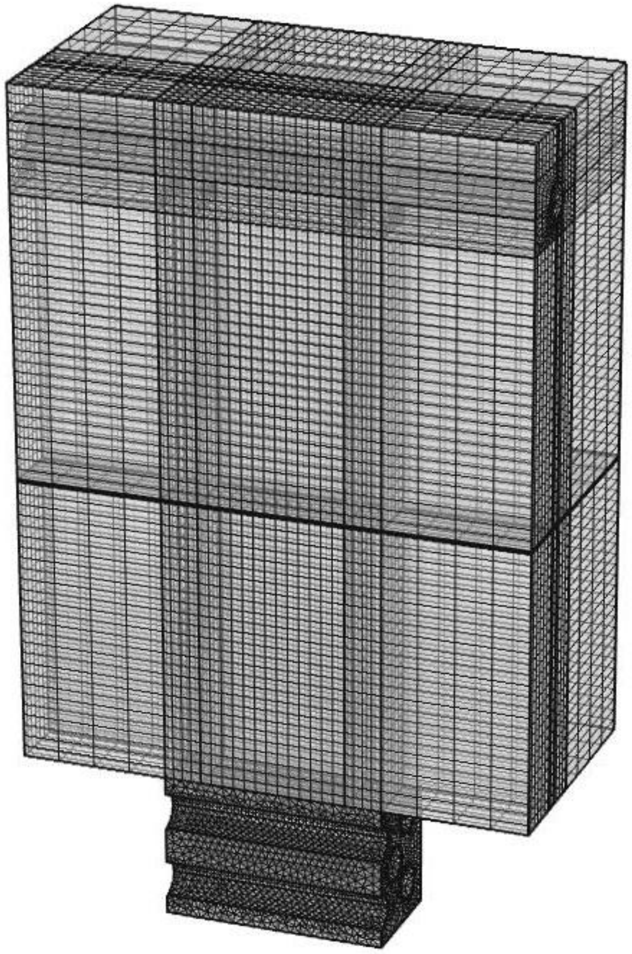

- Hex elements through most of the model, tetrahedral elements in the heat exchanger
- Maximum Element Size: 0.002 m
- 4 elements through the insulation layer: 0.0064 m

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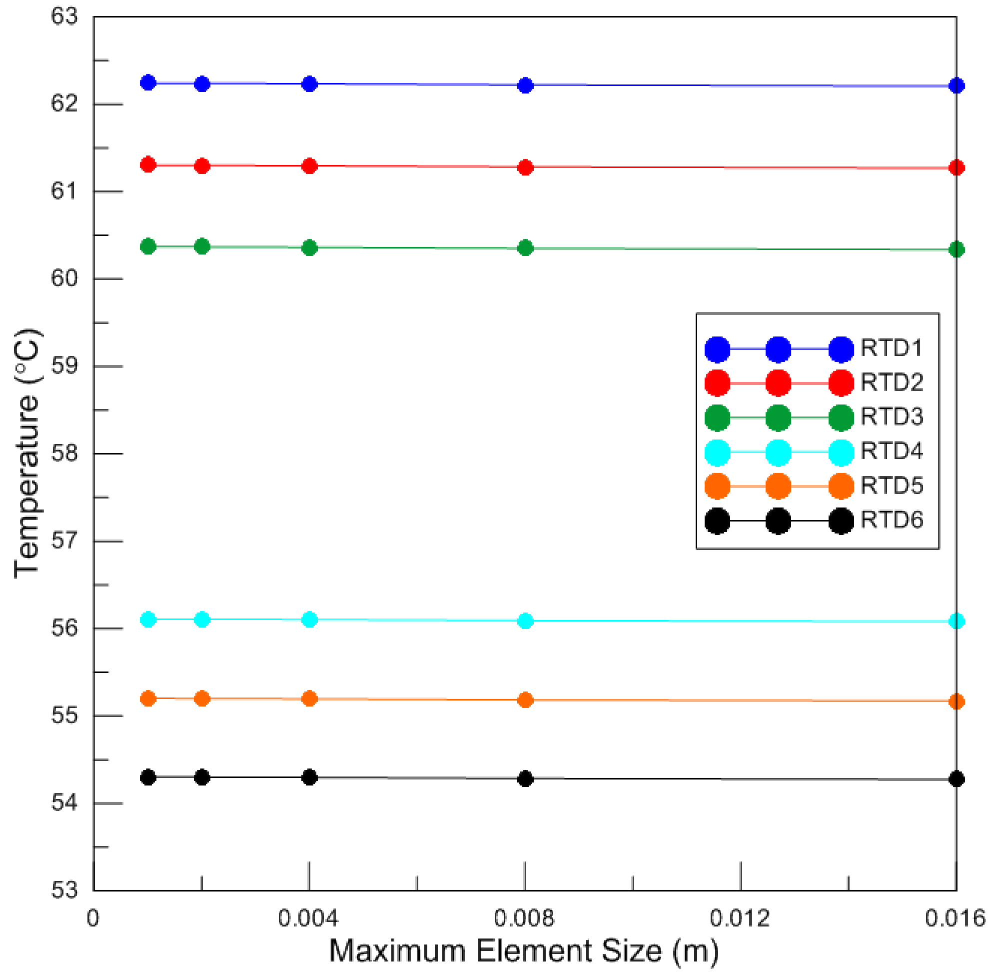

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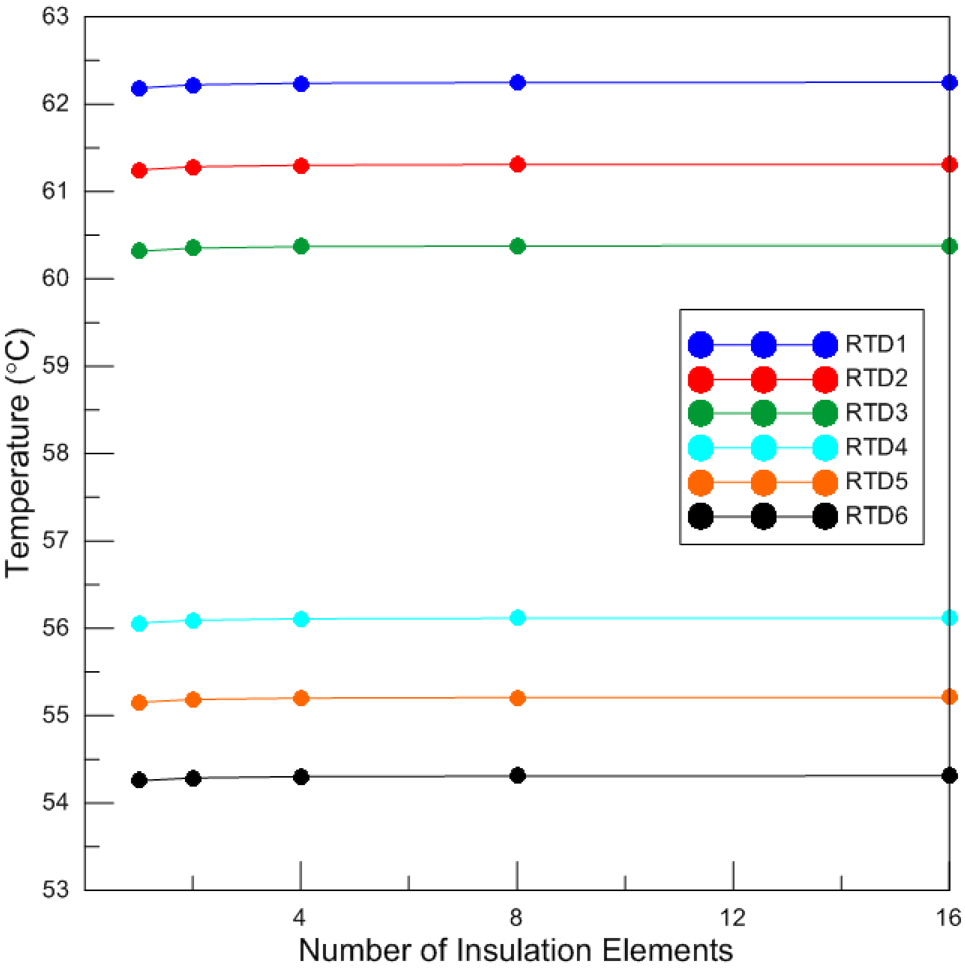

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- To do an initial test of the model the simplest experimental dataset was chosen: No TIM at 0.50 Mpa (73 psi)
- This is a well understood case with few heat losses. Model is expected to match the one dimensional case well.

$h_{lateralheatloss}$	2.0 W/m^{2}K
$h_{heatsink}$	36.1 W/m^{2}K
$q_{topheatloss}$	1.1 W
θ	?

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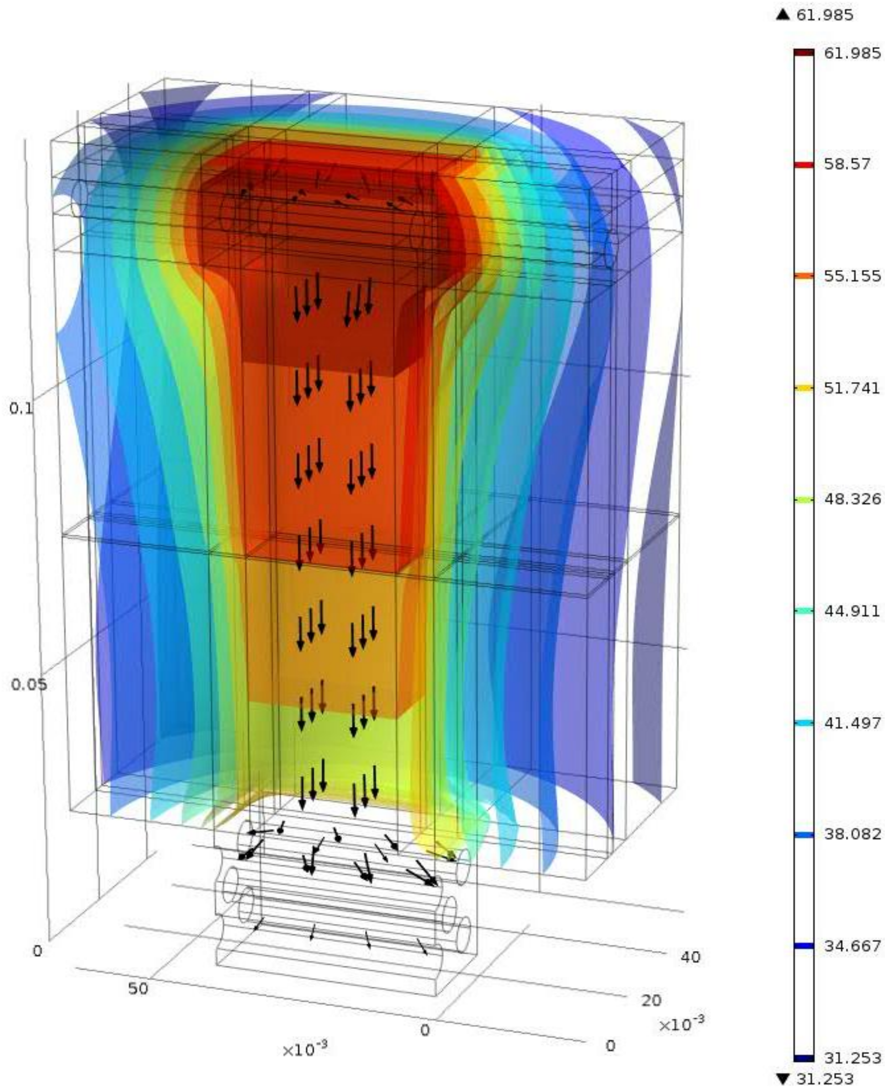

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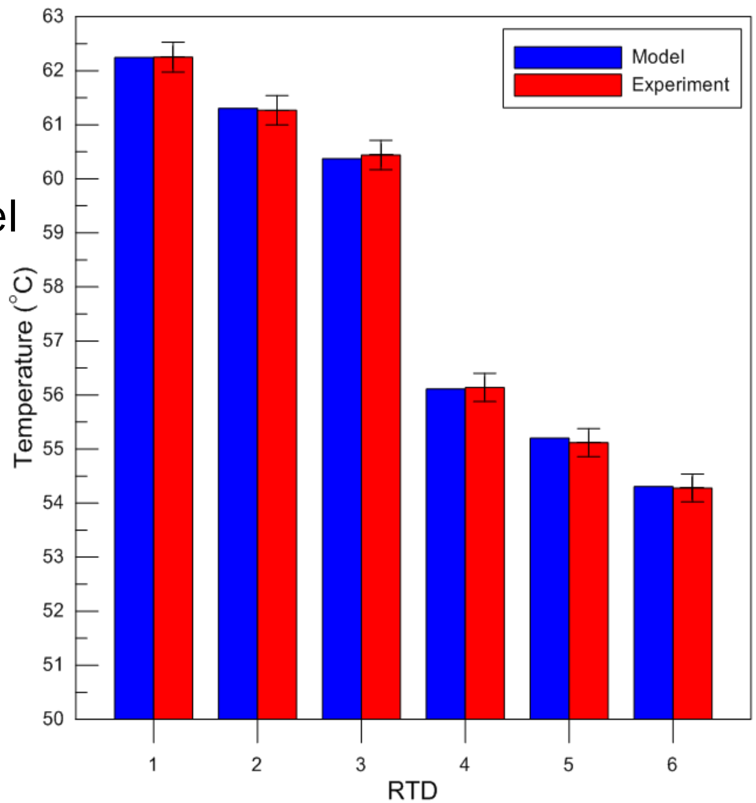

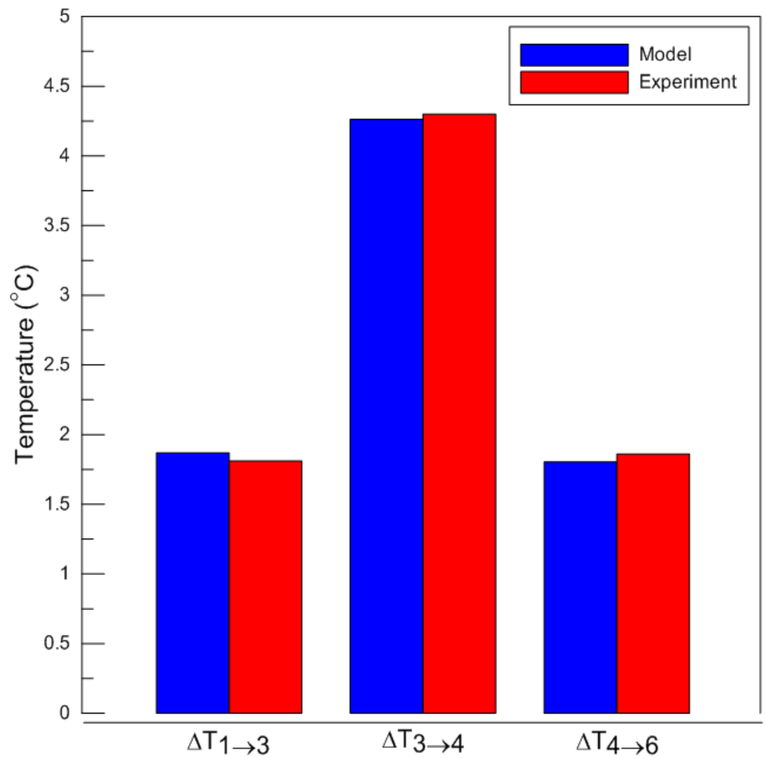

$\theta_{model} = 0.5\ W/cm^2K \quad \theta_{exp} = 0.49\ W/cm^2K$

CONCLUDING REMARKS

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- Initial comparisons with experimental data indicate that the FEA simulation works well.
- Further comparing the model to more data sets, especially higher temperature tests where heat losses will be more significant, is the next step.
- A sensitivity analysis on the FEA model would also be useful.

REFERENCES

1. J. P. Gwinn, R. L Webb, Performance and testing of thermal interface materials. Microelectronics Journal, 34, 215-222, (2003)