Improvement of a Steady State Method of Thermal Interface Material Characterization by use of Three Dimensional FEA Simulation in COMSOL Multiphysics

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Introduction: A common method for characterizing thermal interface materials (TIMs) is typified by ASTM D5470 – 06. This method is a steady state method of characterization which approximates a one dimensional heat transfer through the TIM sample. The Lab of Applied Multiphase Thermal Engineering at Dalhousie University built and tested a steady state test apparatus of this type. Figure 1 shows a simplified schematic of this type of test apparatus and Fig. 2 shows a photograph of the actual setup.

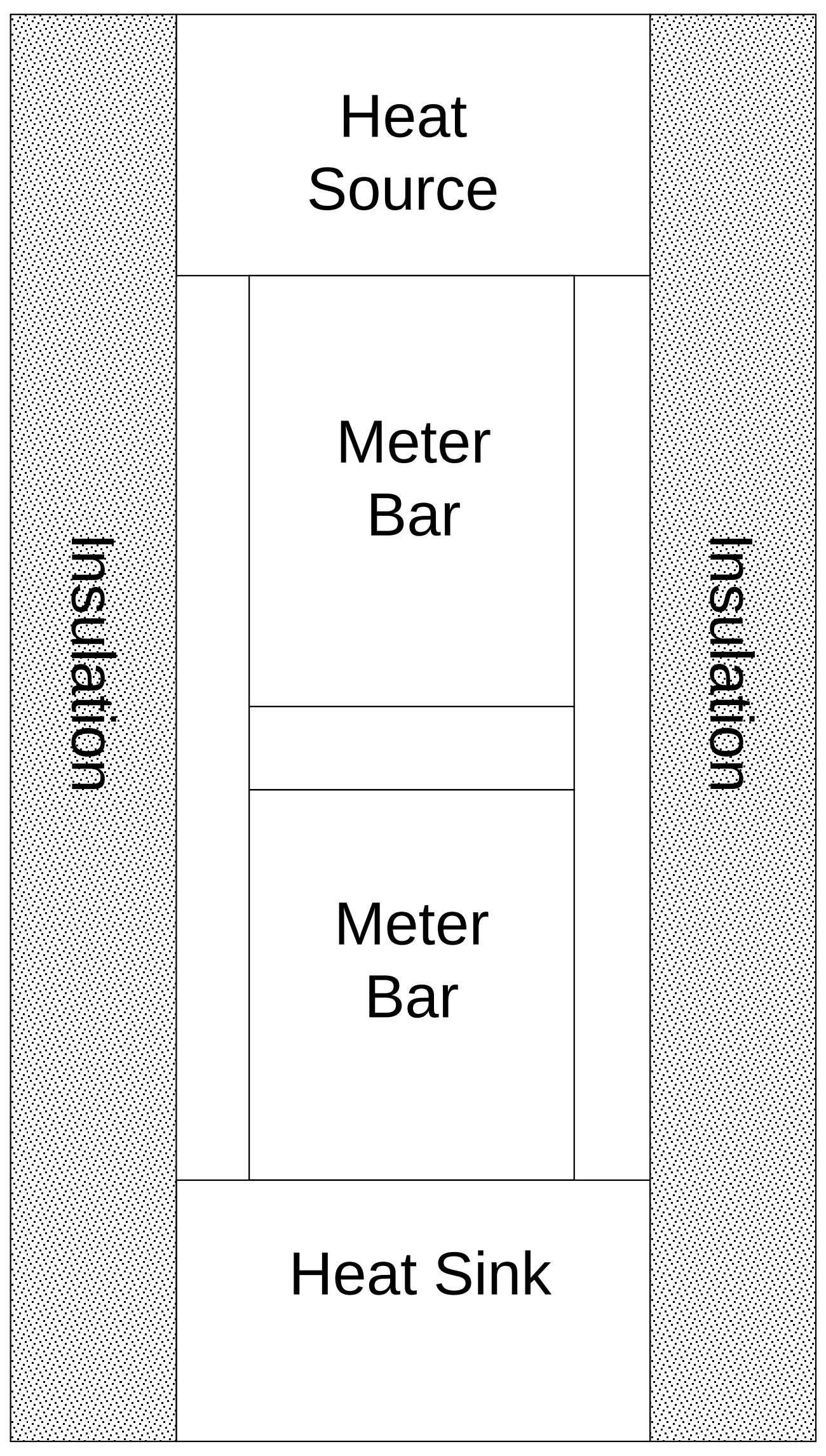

Figure 1. Illustration of steady state apparatus

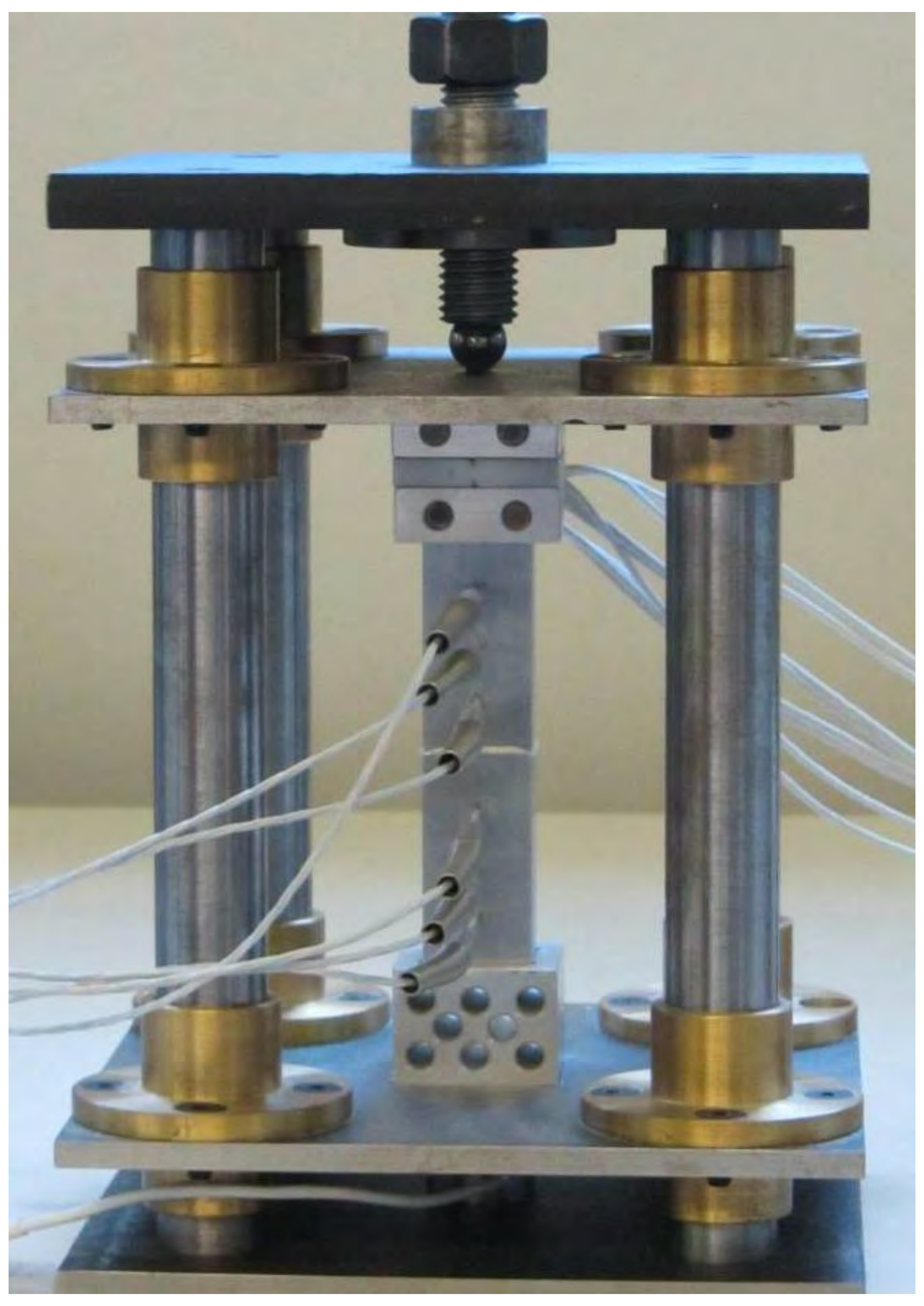

Figure 2. Photograph of steady state apparatus

As a result, of the one dimensional assumption used by the standard method to determine the conductance, any heat losses or non uniformity in the heat flux will contribute to the experimental bias. The goal of this work was to create a three dimensional FEA model of the experimental apparatus using COMSOL Multiphysics and then use that model to calculate the conductance of a TIM layer bases on experimental data.

Model: The experimental setup was modeled in three dimensions using conduction for all internal heat transfer and simple convection to ambient (25˚C) on the boundaries. A hybrid mesh of quadrilaterals and tetrahedrons was used to discretize the domain. A maximum elements size of 0.002 m was used in the: heater, meter bars and heat sink . The mesh was made courser in the out insulation with the element count going out through the insulation set to 4 elements (giving a length of 0.25 in or 0.0064 m). Figure 3 shows the final mesh used in the simulation. Table 1 summarizes the materials used in the simulation.

Table 1. Materials used in the simlaution

Material	Density (kg/m³)	Thermal Conductivity (W/mK)	Specific Heat (J/kgK)
ASIS 4340 Steel	2700	167	900
Superwool 607	335	0.06	0.243
Macor	2520	1.46	790
Air	COMSOL Materials Database		

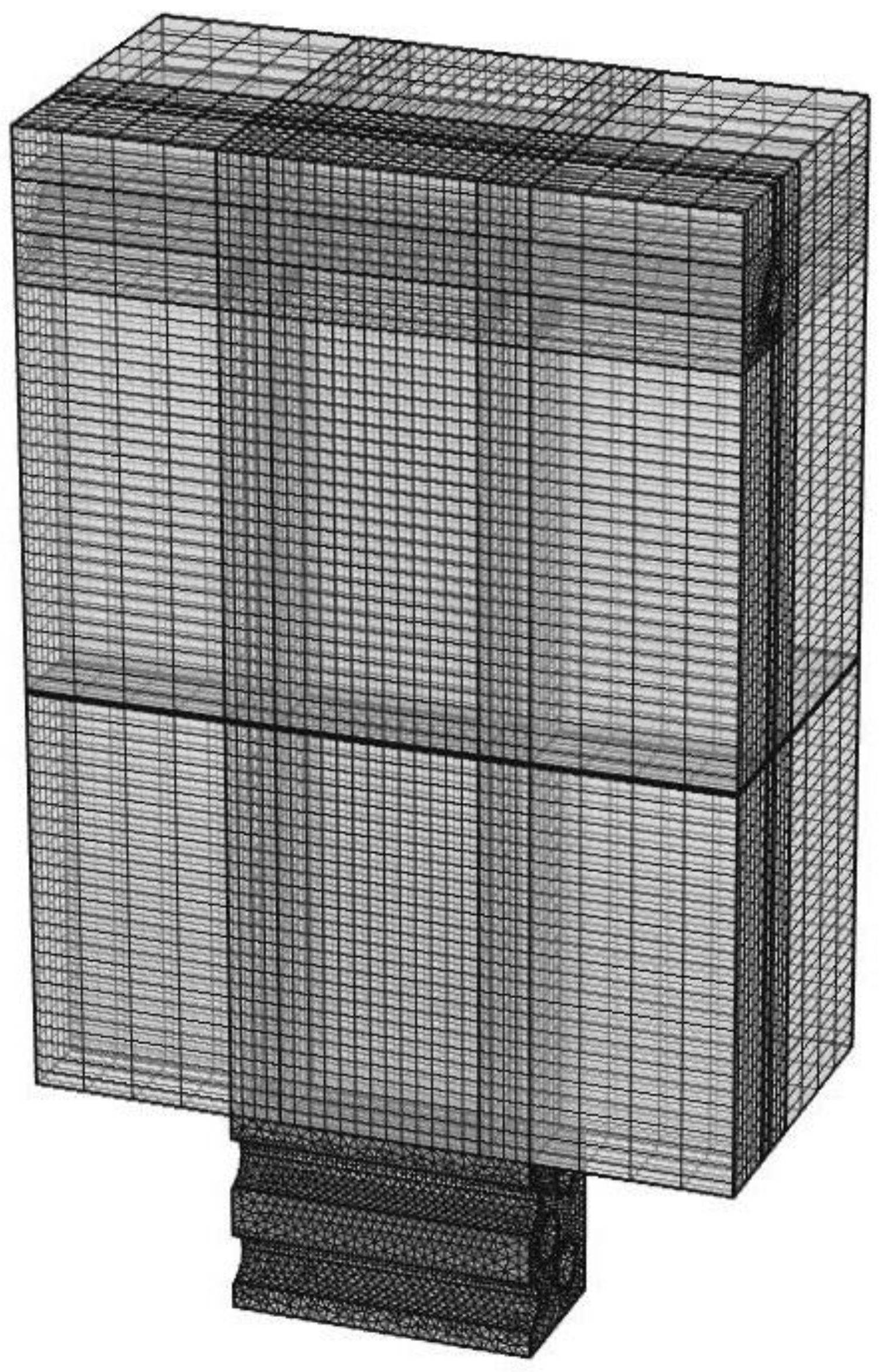

Figure 3. Model mesh

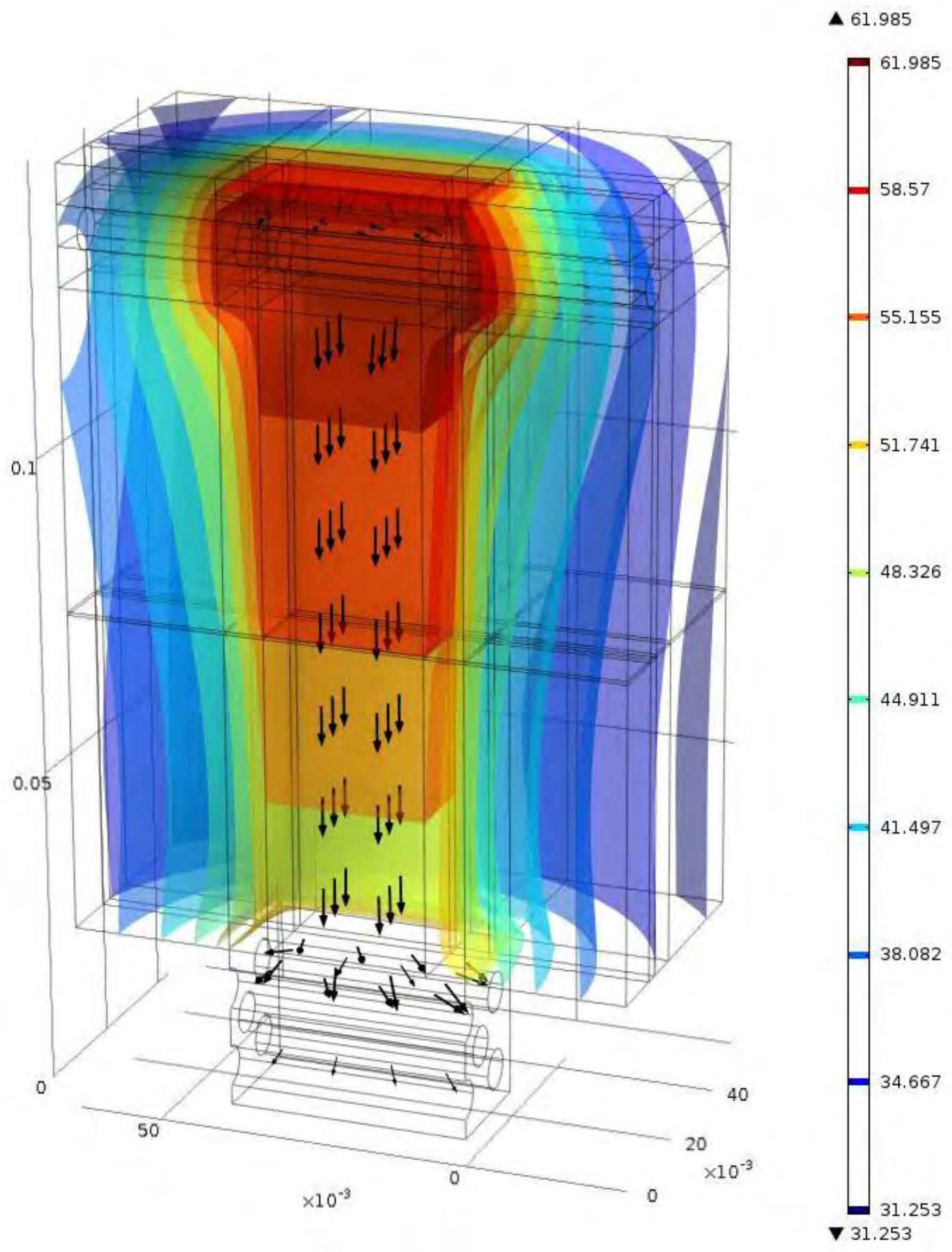

Figure 4. Simulated temperature distribution

Results: Three different heat loss parameters and the conductance of the TIM layer were used to fit the model to a set of experimental data taken from the steady state characterization device. More specifically a test with no TIM in the interface at 73 psi (0.5 Mpa). Table 2 summarizes the fitting values used in the model and Fig. 4 shows an isothermal surface plot of the temperature output from the model. Figure 5 shows the comparison between the model temperature outputs and the experimental measurements.

Table 1. Heat loss coefficients and TIM conductance used to fit the model

$h_{LateralHeatLoss}$	36.1	W/m²K
$h_{HeatSink}$	2	W/m²K
$q_{TopHeatLoss}$	1.1	W
Conductance	**0.5**	**W/cm²K**

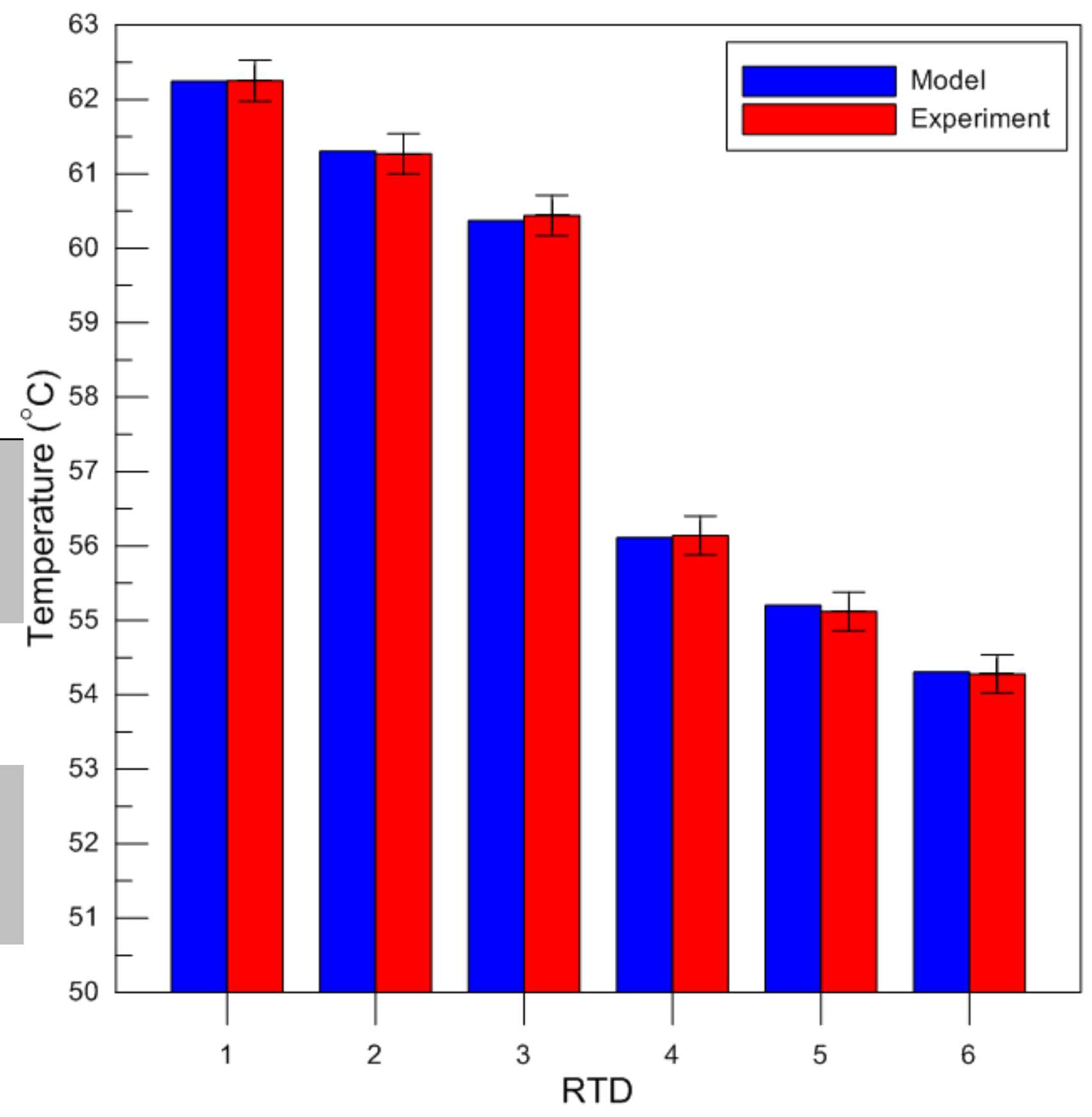

Figure 5. Comparison of simulated & experimental temperatures

Conclusions: Using the above fitting parameters the simulation temperatures matched the experimental values. A value of 0.5W/cm²K was found for the conductance of the TIM layer which compares well with 0.49 W/cm²K calculated using the standard one dimensional method.

COMSOL
CONFERENCE
BOSTON
2012

Excerpt from the Proceedings of the 2012 COMSOL Conference in Boston