Improvement of a Steady State Method of Thermal Interface Material Characterization By Use of a Three Dimensional FEA Simulation in COMSOL

Benjamin Sponagle[1], Dominic Groulx[1]

[1]Mechanical Engineering, Dalhousie University, Halifax, NS, Canada

Abstract

Interface conductance refers to the ease with which heat can be transferred across an interface between two surfaces which are in contact. When two surfaces are pressed together, only a small percentage of the nominal area will be in direct contact due to surface imperfections such as flatness and roughness. Air gaps formed as a result, serve to decrease the thermal conductance associated with transferring heat across the interface. A common engineering problem where interface conductance is of interest is microchip cooling systems. More powerful chips tend to dissipate more heat. In order to, increase the power of a microchip design, while maintaining the operating temperature, the rate at which heat is removed must be optimized. The conduction path from the microchip to the heat sink will include at least one interface (more if a heat spreader is used). The conductance of an interface is improved by the use of thermal interface materials (TIMs). TIMs are deformable materials which can be placed into the interface. The TIM will conform to the surface irregularities filling the air gaps. The performance of a particular TIM is determined by both its effective thermal conductivity (TIMs are rarely homogeneous), its ability to conform to the surface irregularities, and the thickness of the layer it forms within the interface. Therefore, TIM performance cannot be defined using a simple bulk property such as thermal conductivity. It must be tested in an interface in order to get a true measure of its performance. One method for characterizing the conductance of an interface with a TIM applied is the steady state method characterized by ASTM D5470 - 06. The premise of this experiment is to setup a controlled heat flow through an interface with an applied TIM and then measure the temperature drop across that interface (see Figure 1). The temperature gradient along the two meter bars is measured and then the temperature at the hot side (TH) and cold side (TC) of the interface are extrapolated. The conductance of the interface 'theta' (W/cm2K) can then be calculated using the following equation: theta=Q/(A(TH-TC)). Where Q is the heat transferred through the interface and A is the area of the interface. This calculation assumes that the test system is one dimensional. Heat losses from the sides of the assembly or non-uniformity in the heat source and sink will introduce experimental bias. The authors used COMSOL 4.2a to build a three dimensional FEA simulation of the above test apparatus. The results of this model were then fitted to experimental data from previous steady state characterization trials. By doing a one parameter curve fit of the model results to the experimental data the conductance of the layer could be calculated while taking into account non one dimensional effects. This model will also allow for a better understanding of the relative importance of these non one dimensional effects in determining the conductance. Figure 2 shows the model

mesh and Figure 3 shows a preliminary run of the simulation.

Figures used in the abstract

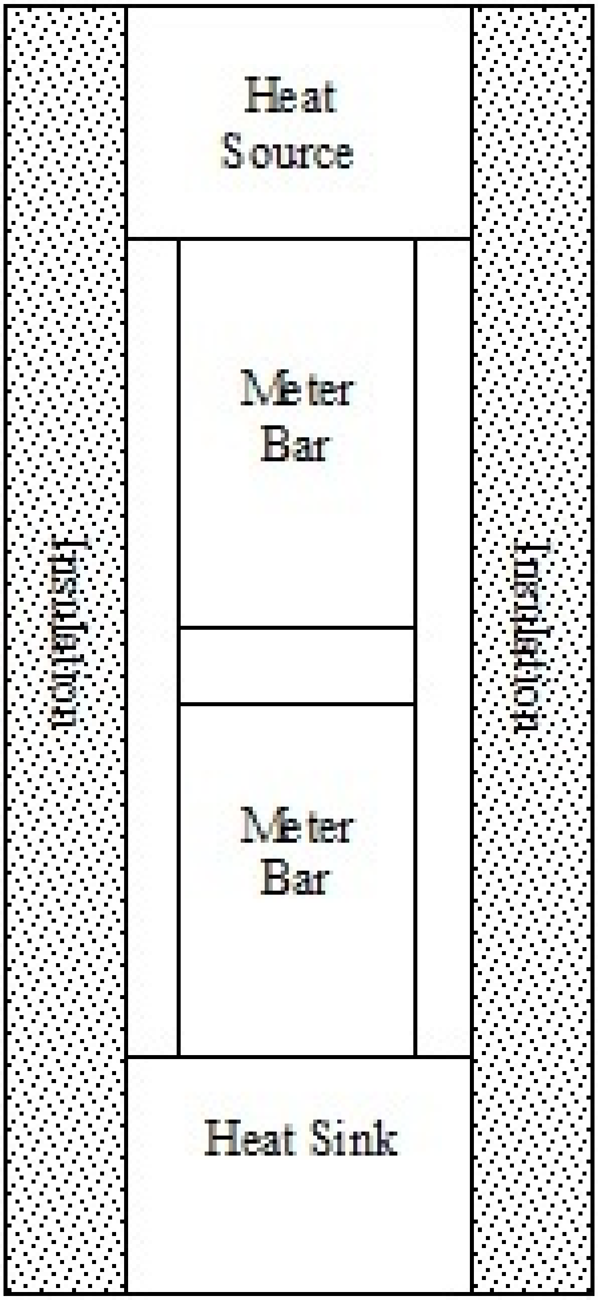

Figure 1: Simplified schematic of a steady state TIM characterization experiment

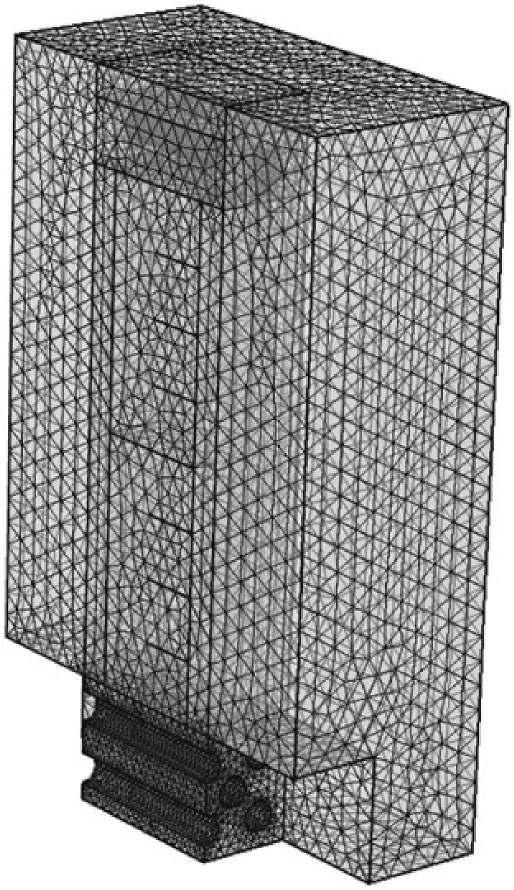

Figure 2: Meshed COMSOL model of the stead state TIM characterization setup

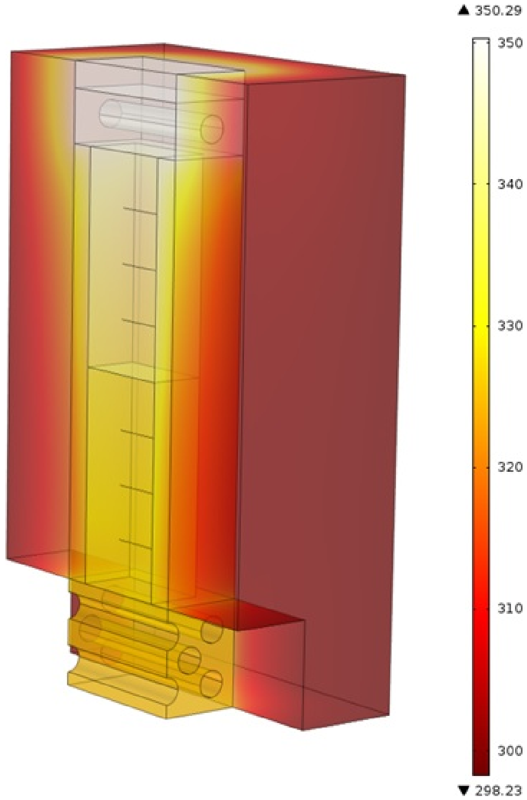

Figure 3: Preliminary temperature (K) results from the COMSOL model