Micromechanical Design of Novel Thermal Composites for Temperature Dependent Thermal Conductivity

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Introduction: Material with an order variable in thermal conductivity as a function of temperature is desirable for thermoelectric heat energy recovery, building thermal insulation and solar thermal applications. This paper mainly focuses on the commercially available constituent materials and leverages composite material principle to design the material for the variable thermal conductivity as a function of temperature.

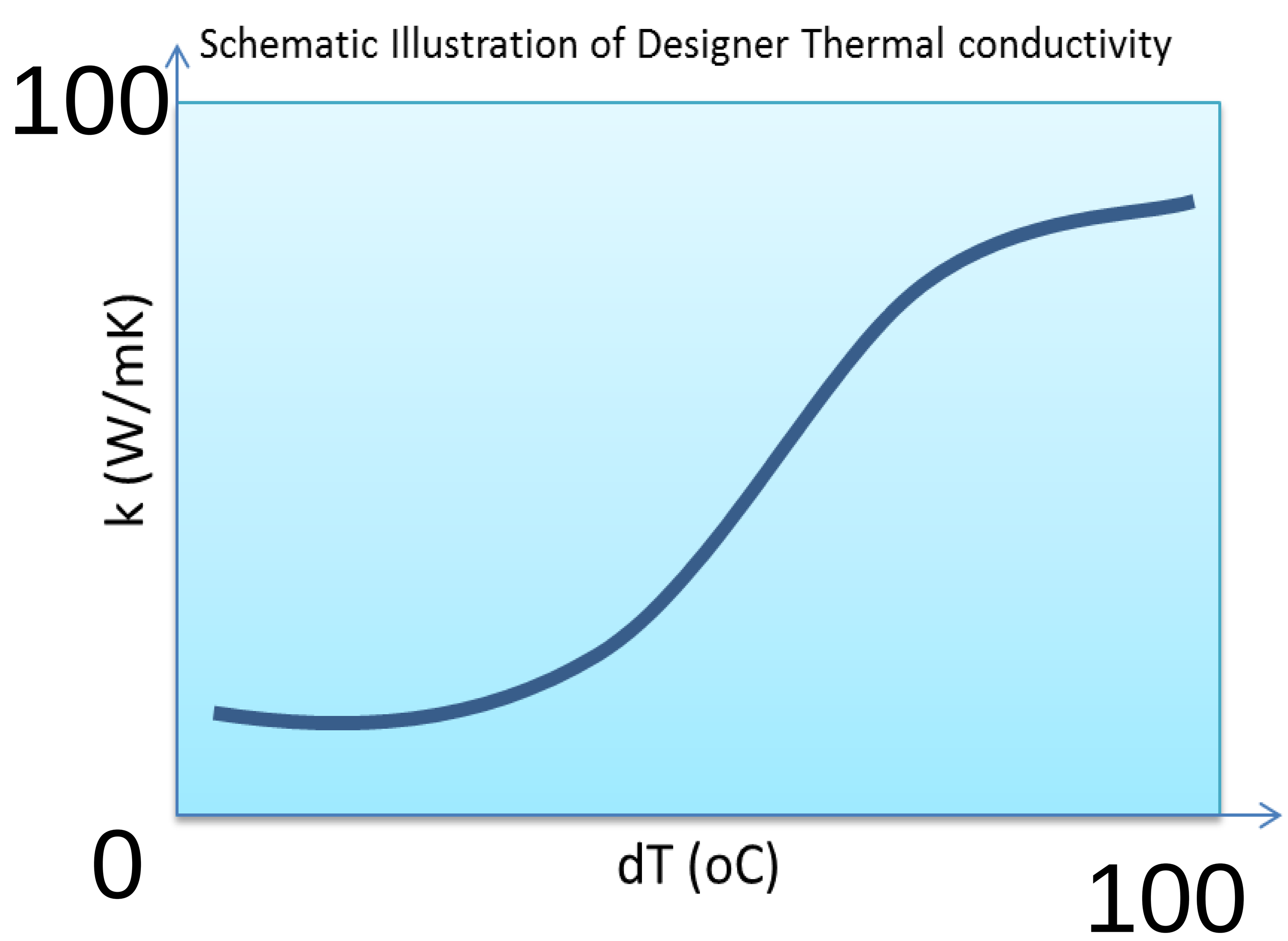
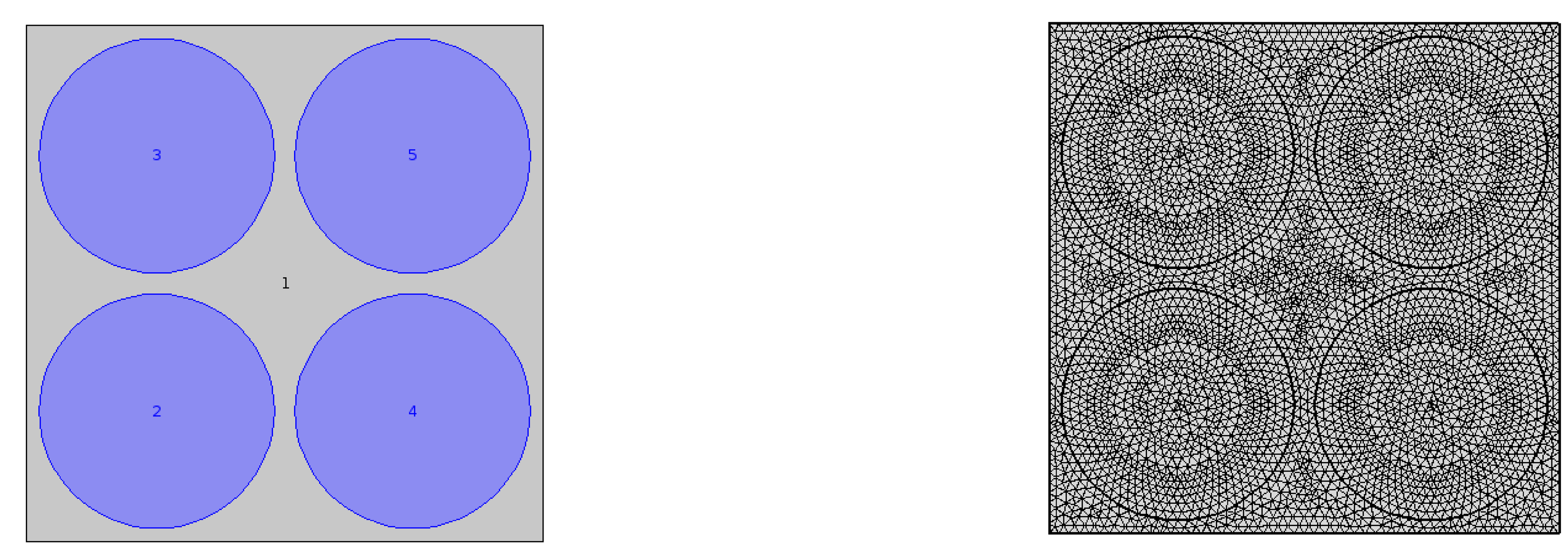


Figure 1. Schematics of Temperature dependent thermal conductivity Material Design.

Computational Methods: Application of composite material principle to design materials with designer thermal property by engineering existing material and morphology. The multiphysics coupling and parametric modeling capability of COMSOL is leveraged for novel material design. Coupled structural and heat transfer + micromechanical simulation. The Thermal Stress multiphysics interface which combines Solid Mechanics and Heat Transfer is used.

Results: Figure 2 shows the CAD model, FEA mesh, predicted thermal conductivity and heat flux magnitude contour plots at low and high temperatures, respectively. The coupled simulation results shows that the thermal conductivity is low at around room temperature (22 ^{o}C) and high at high temperature (~100 ^{o}C) and is reversible and works on composite principle.



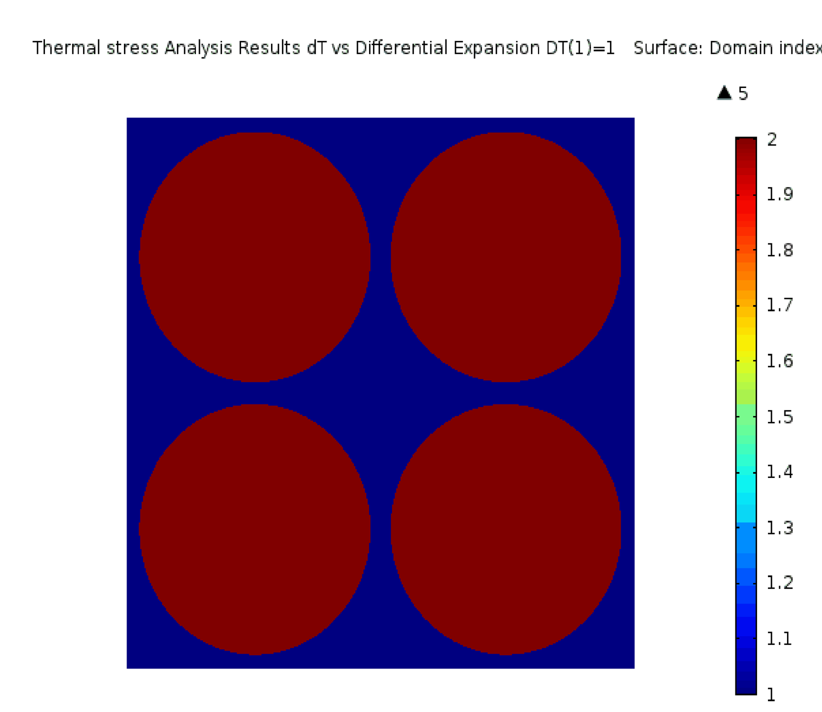
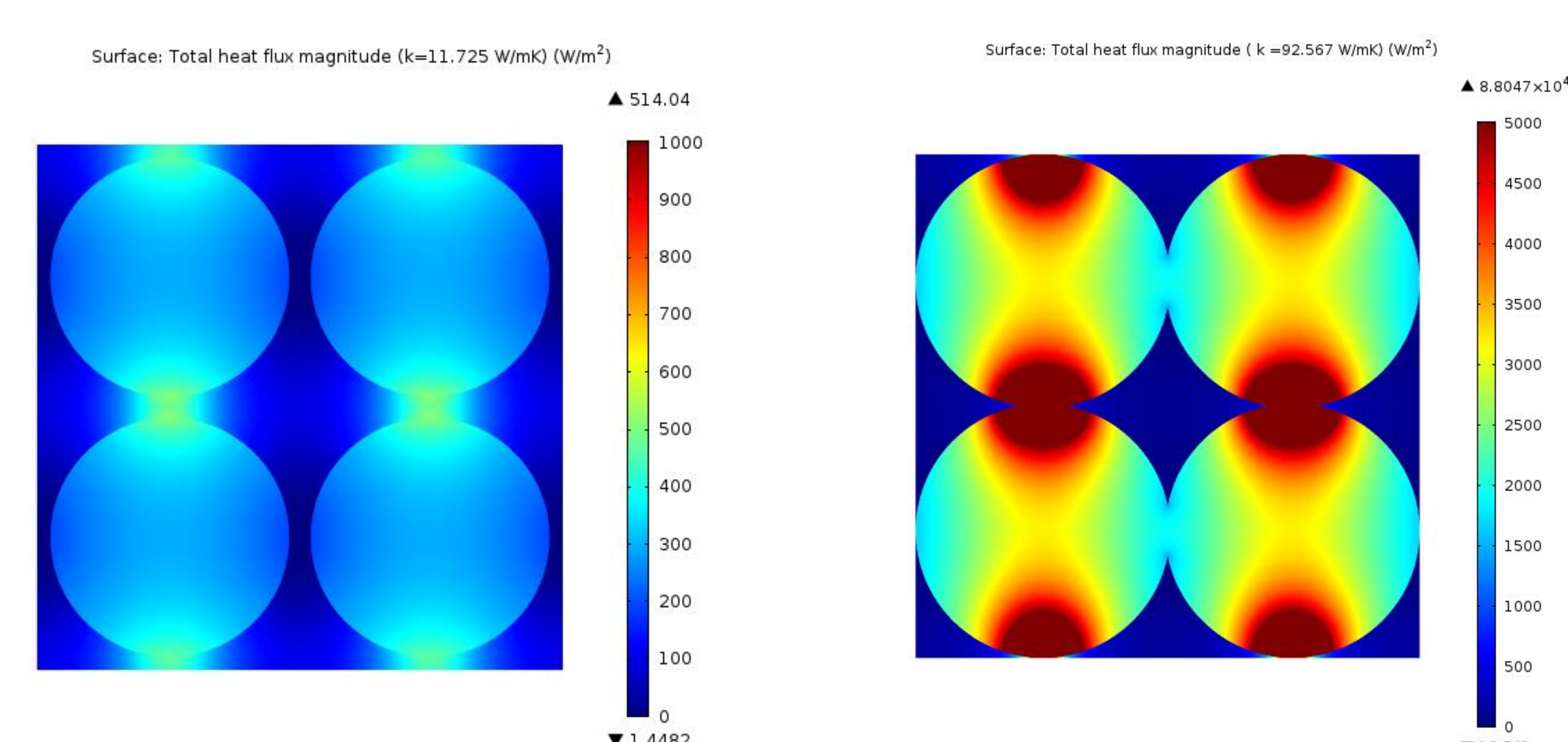


Figure 2. Coupled Thermal stress analysis results: CAD model, FEA mesh, Thermal conductivity, heat flux contour plots.
Thermal conductivity at 22 ^{o}C = 12 W/mK
At 100 ^{o}C = 93 W/mK



Conclusions: Composite micro material mechanics principle by coupling the thermal stress and heat transfer is used to design variable thermal conductivity material for novel applications.

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