Development of a Thermal Diode

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Background

- Analogous to how an electric diode functions with current, an ideal thermal diode would restrict heat flow in one direction and favour it in another
- There is currently little to no control over the flow of heat through mediums with respect to direction
- Such a device would have endless applications in all fields, from HVAC to quantum mechanics
- Just as the electric diode has been paramount to emerging technologies, developing a working model of a thermal diode would transform the world

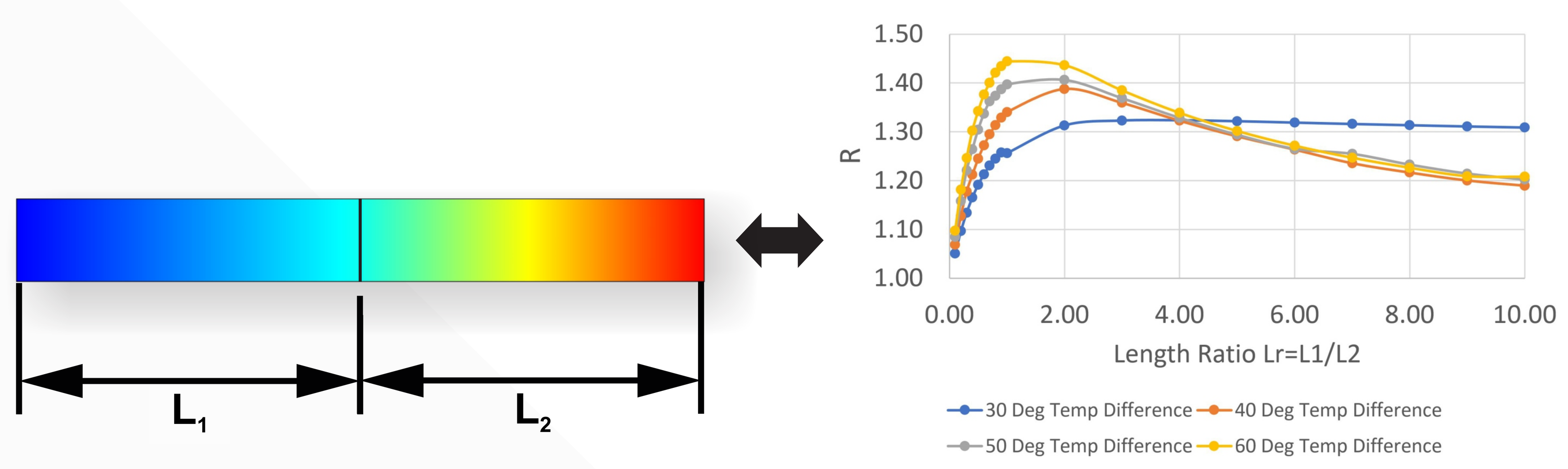
Objective

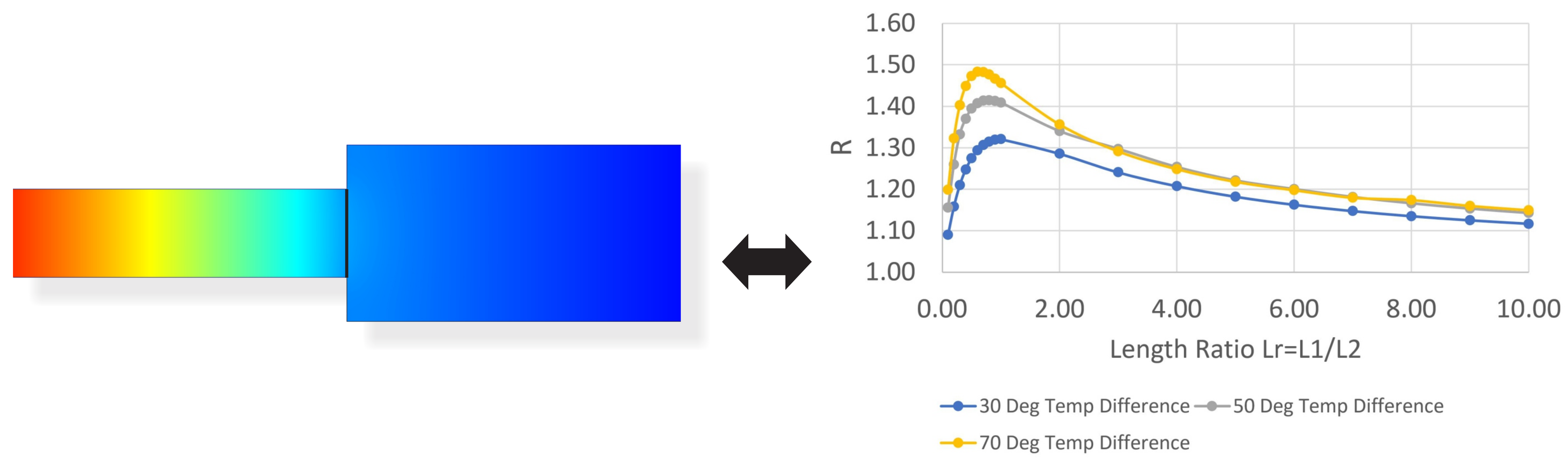
- To further the development of a thermal diode
- Assess existing literature and solutions and develop a design that is as effective
- Identify materials with highly temperature dependant thermal conductivities that will be useful
- Calculate the thermal diode rectification, R, as a ratio of heat flow in the forward direction to heat flow in the reverse direction ($Q_{forward}$ / $Q_{reverse}$)
- Using computer software, simulate multiple different scenarios to determine the relationship between different geometries and materials on heat flow

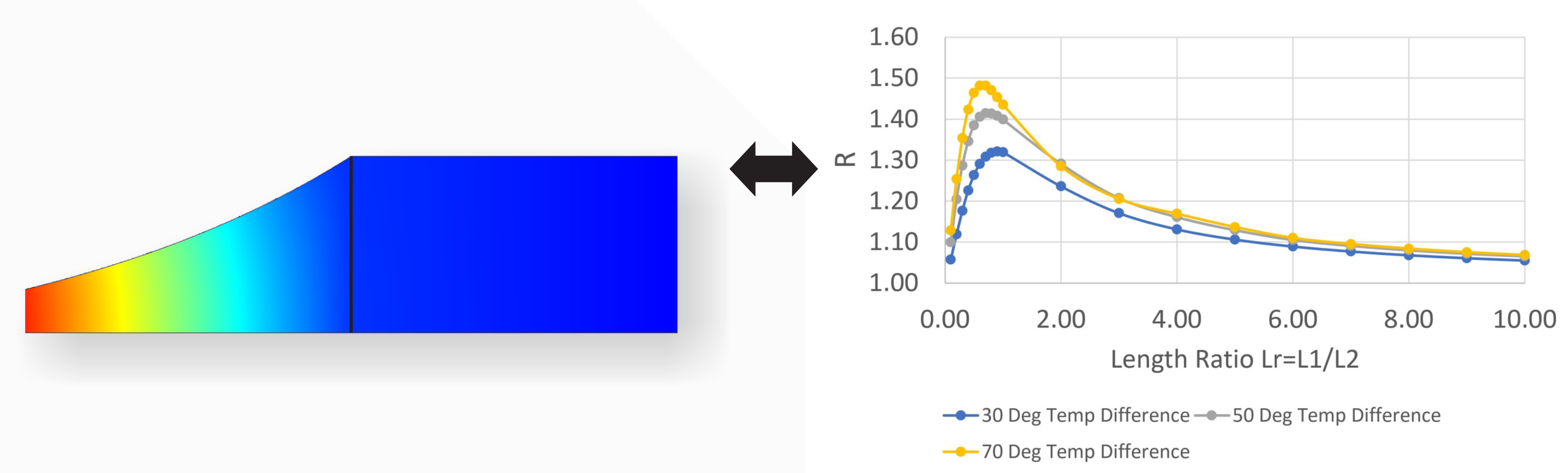
Various Thermal Diode Shapes and Simulated Rectification Coefficients

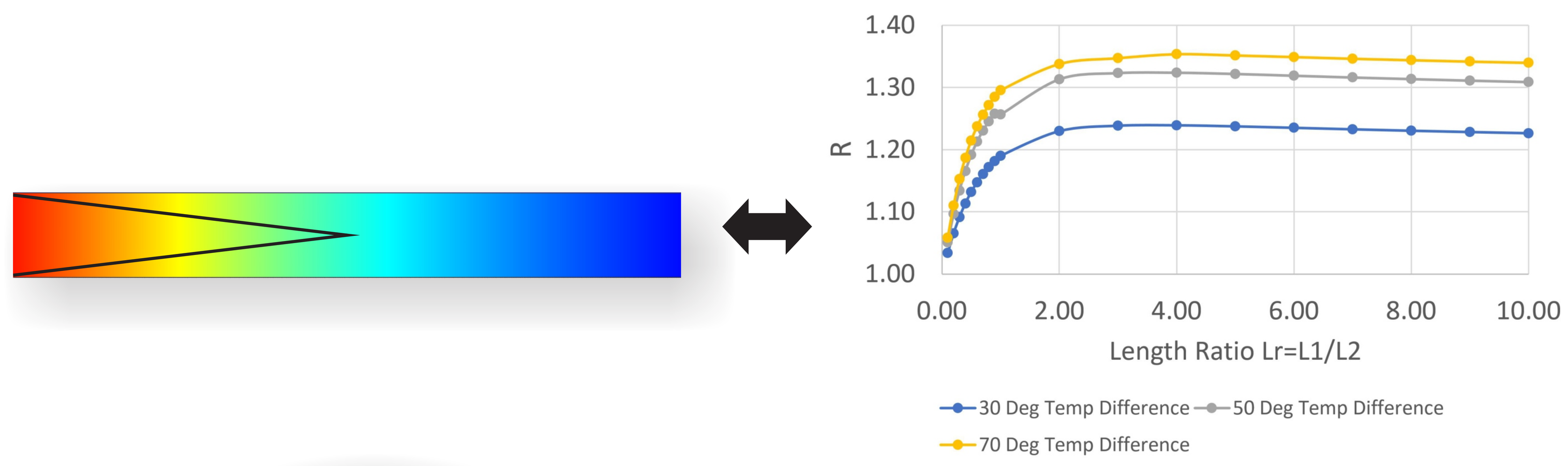
$$R = \frac{\text{Forward Heat Flow}}{\text{Reverse Heat Flow}}$$

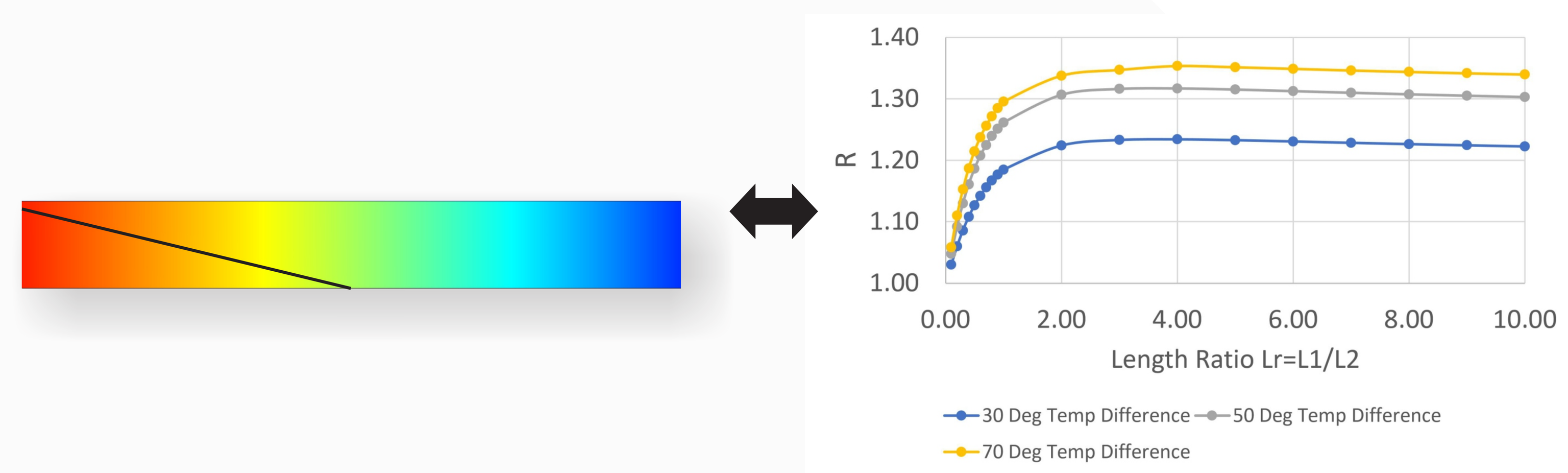
Simulated materials: LCO ($LaCoO_3$) and LSCO ($La_{0.7}S_{0.3}CoO_3$)

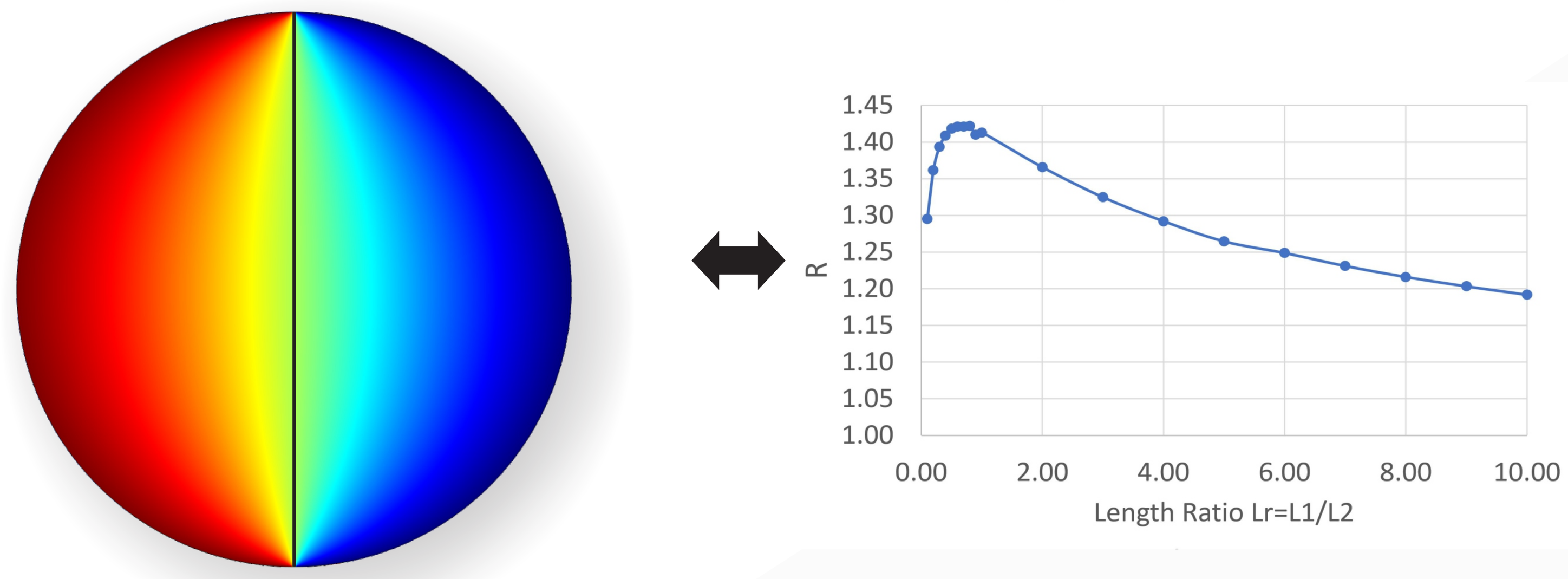












Results

- Many different geometries and material combinations were simulated
- The length ratio parameter defines the ratio between the lengths of both materials in the thermal diode
- By varying the length ratios of each section a maximum rectification coefficient was determined
- Specifically pairing materials LCO and LSCO together, observed up to 48% rectification over a 70ºC temperature range
- Rectangular geometries with vertical interfaces are most successful

Future Work

- Pairing materials with temperature dependant thermal conductivities can influence heat flow
- Solutions are limited to the thermal conductivity capabilities of existing materials
- Computer simulations predict a difference of up to 48% with the chosen materials and geometry
- Thermal Diodes have the potential to significantly impact the modern world
- Further research into more materials and variations

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