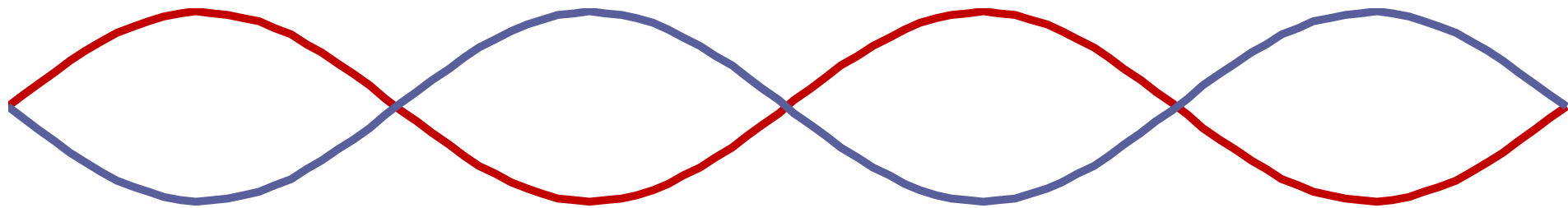
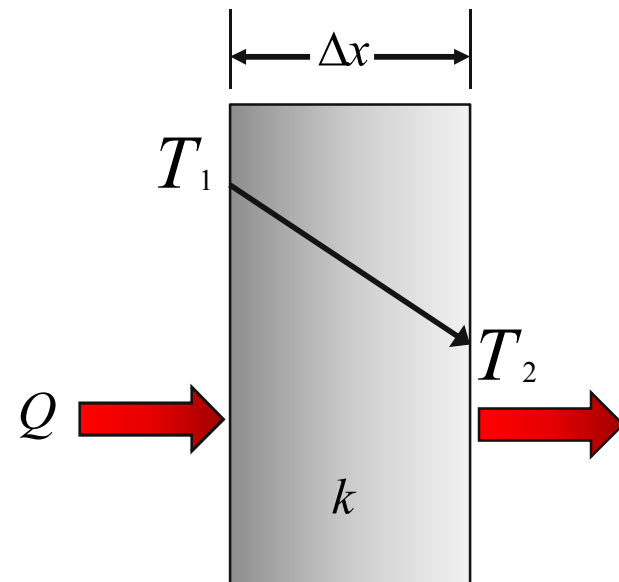


Measuring Thermal Conductivity with Raman: *Capability, Uncertainty, and Strain Effects*



Thomas Beechem and Luke Yates
October 10, 2012

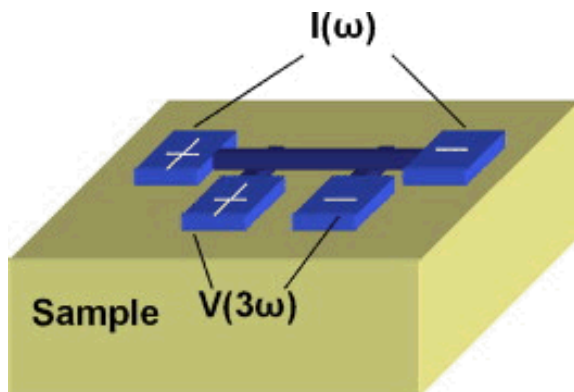
Quantifying Conductivity



$$k = -Q \left(\frac{\Delta T}{\Delta x} \right)^{-1}$$

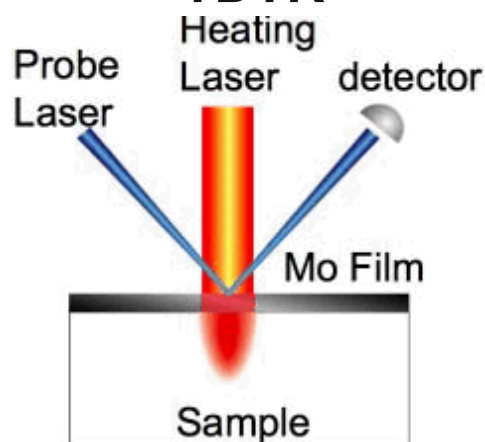
Measuring K in “Small” Materials

3 ω Method



Apanius et al. Sensors & Actuators
(140) 168. 2007

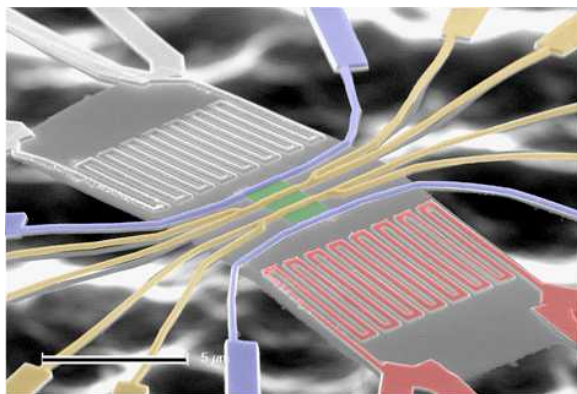
TDTR



www.nist.gov

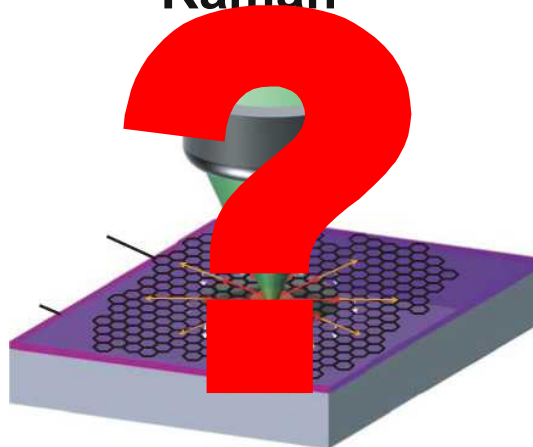
(Thermoelectric Measurements)

MEMS Platform



Hochbaum et al. Nature
(451) 7175 2008

Raman



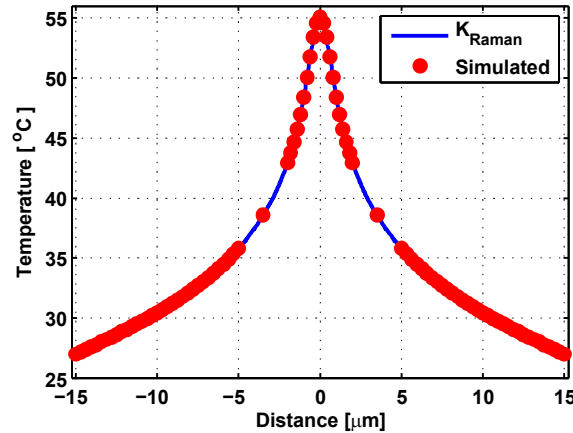
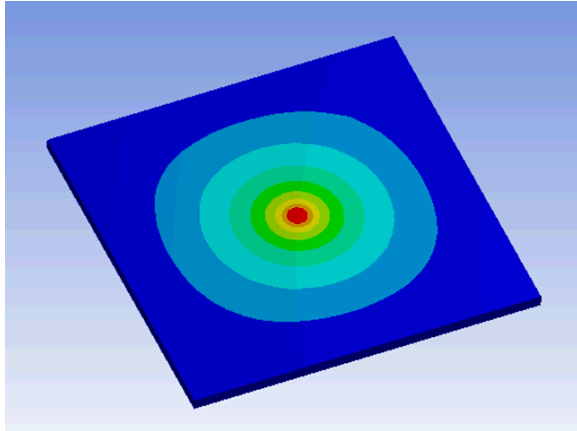
Lee et al. PRB (83) 081419 2011.



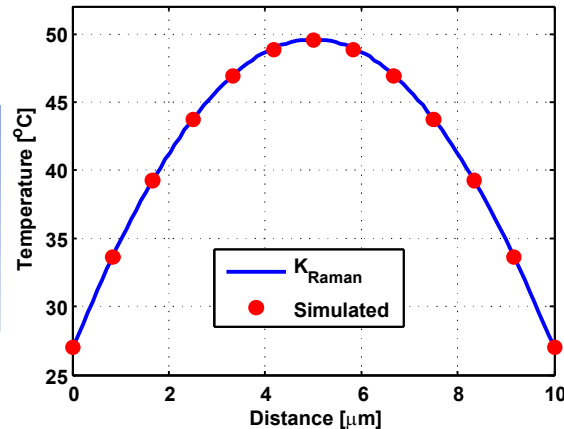
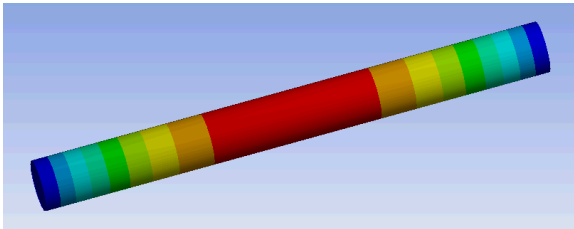
Sandia
National
Laboratories

“Measuring” Thermal Conductivity

Laser Heating: Chip Geometry



Joule Heating: Rod Geometry



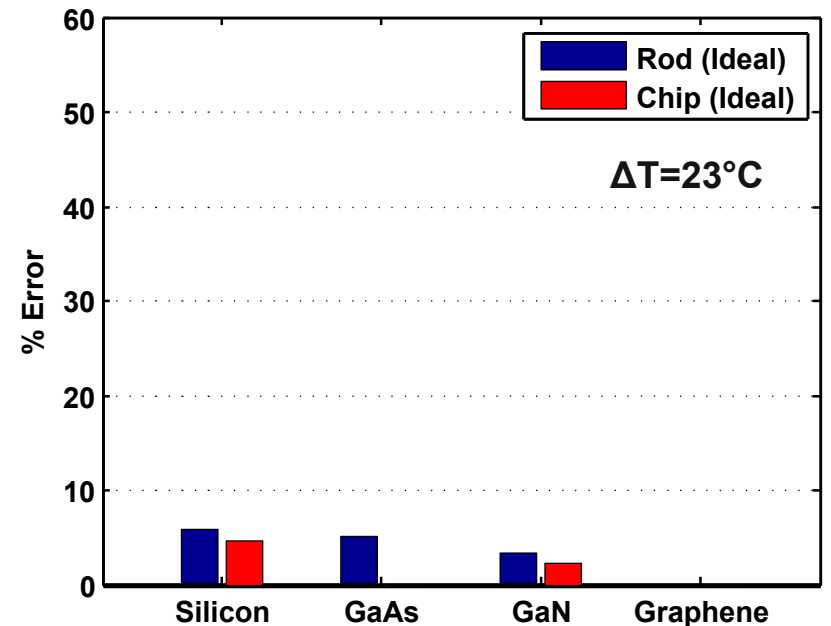
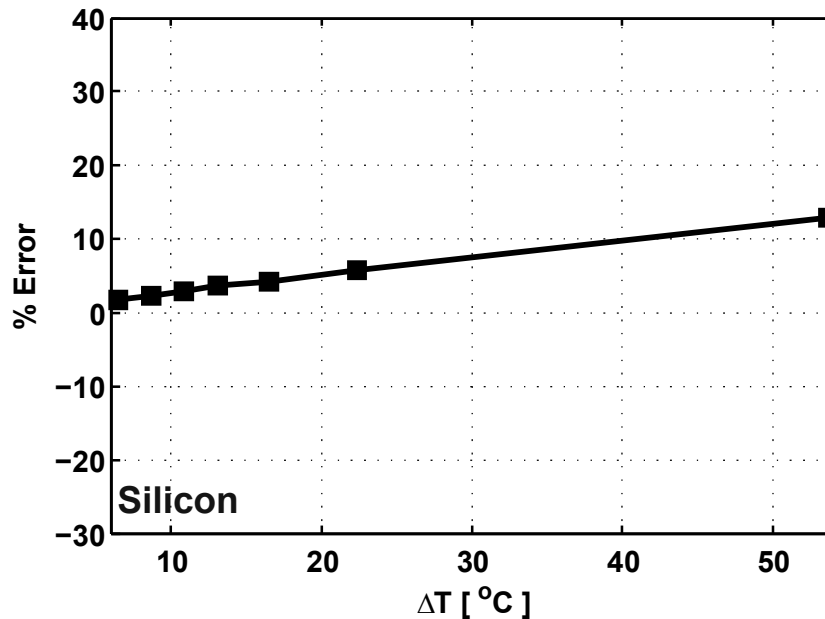
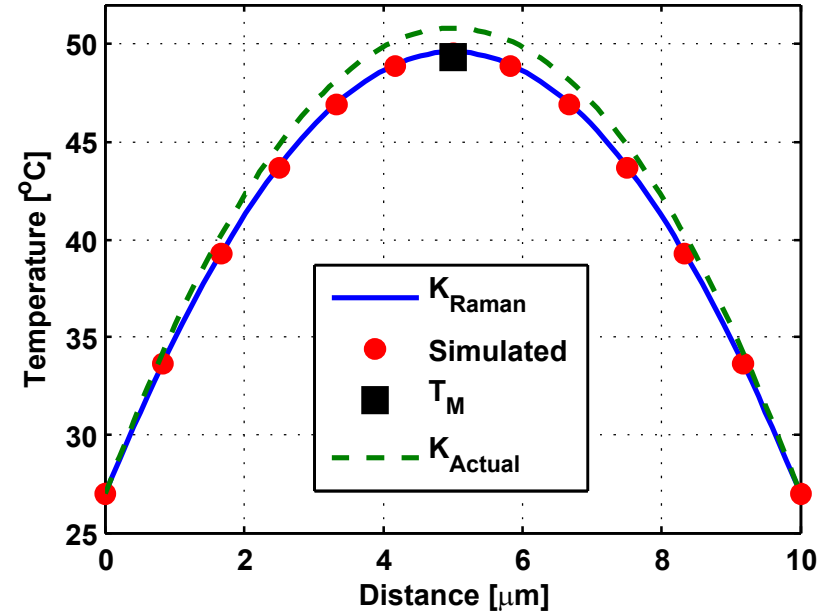
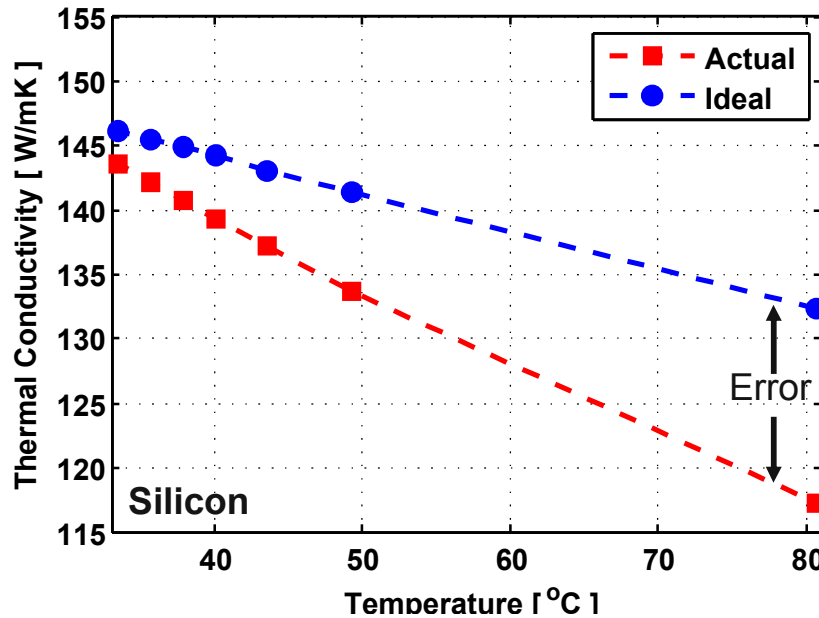
Virtual Experiment
(Simulation)

Extract “Measured”
Raman Temp. (T_m)

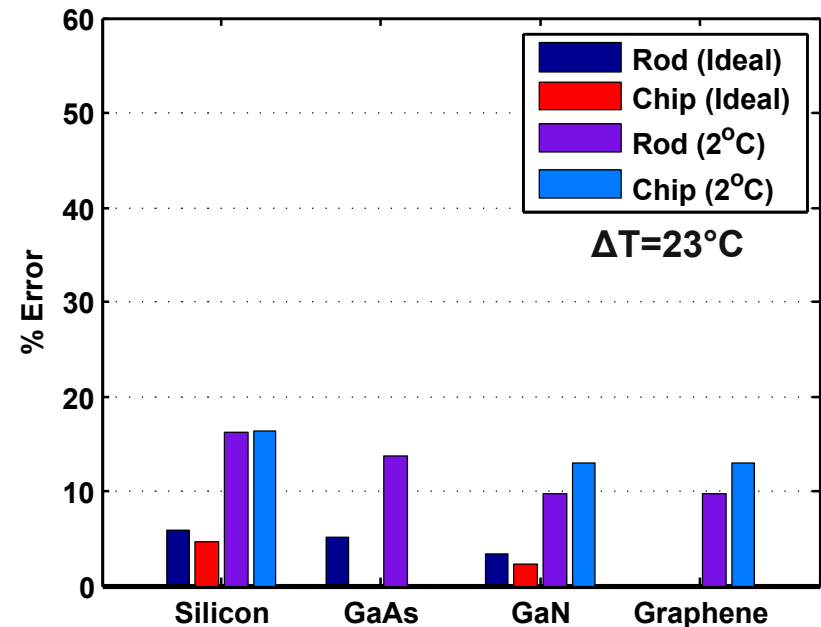
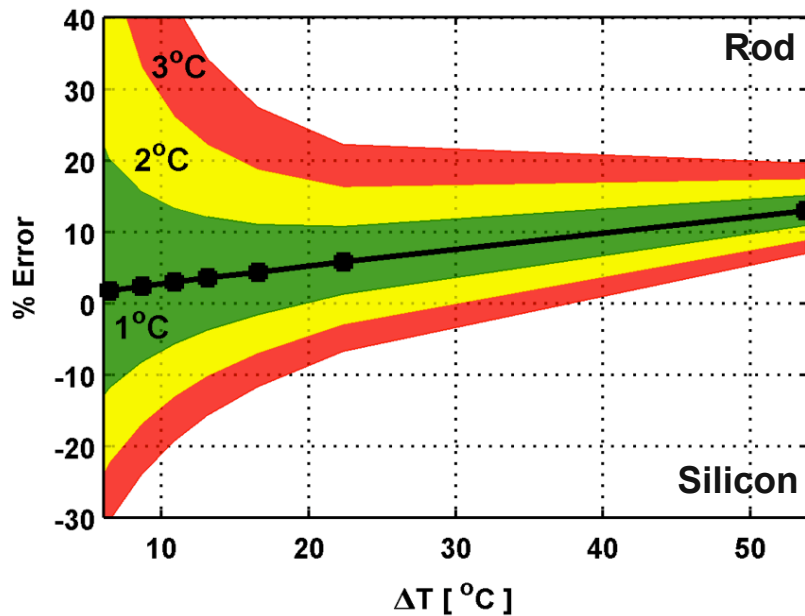
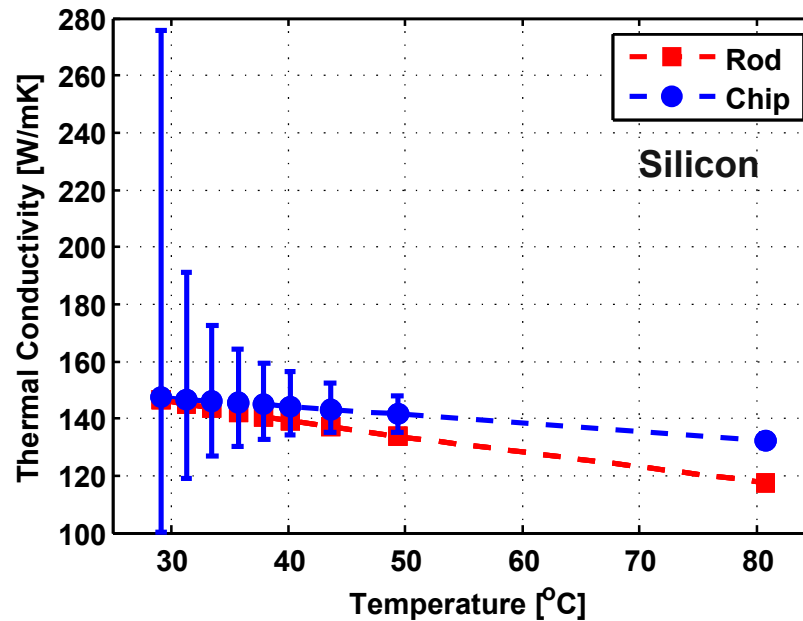
Analytical Model

Fit K to get T_m

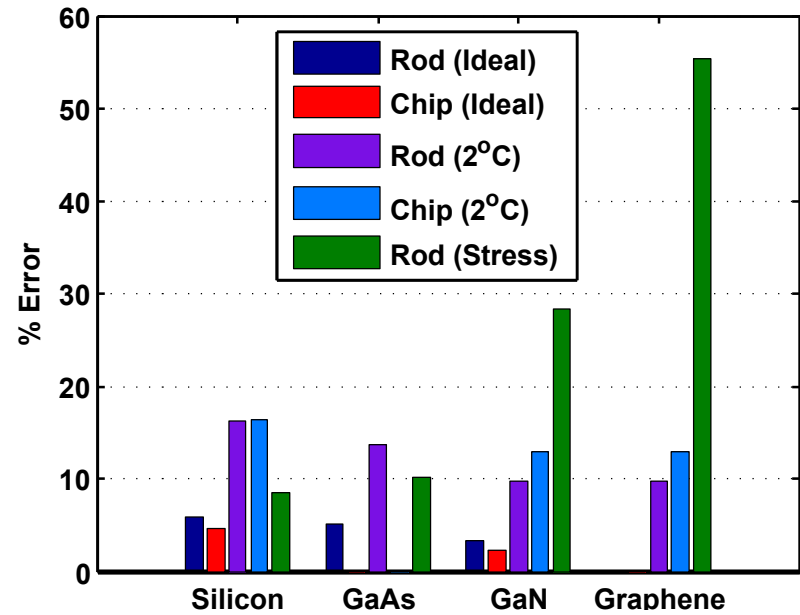
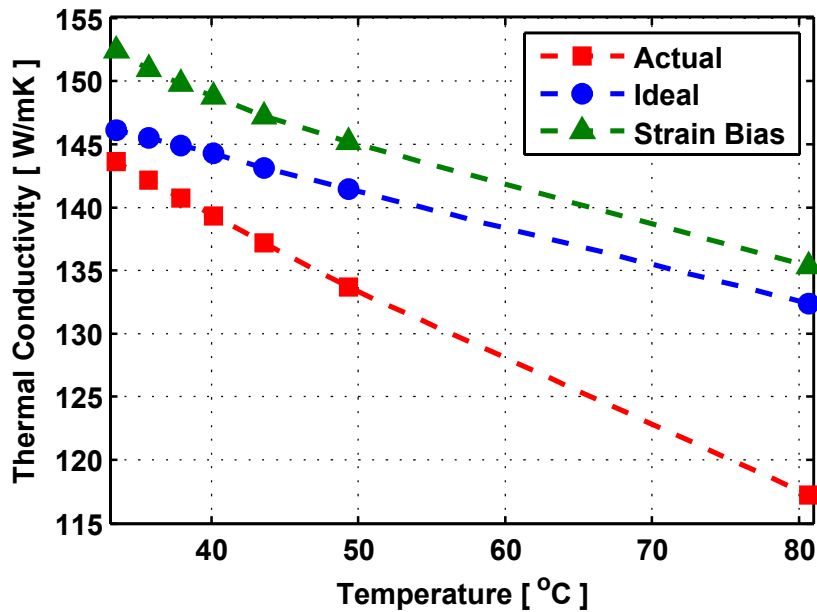
How good could it be? Ideal Case



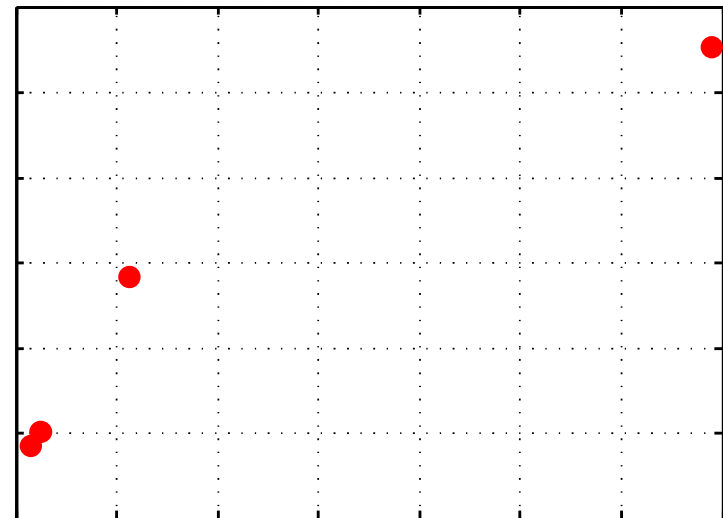
How good is it really? Uncertainty



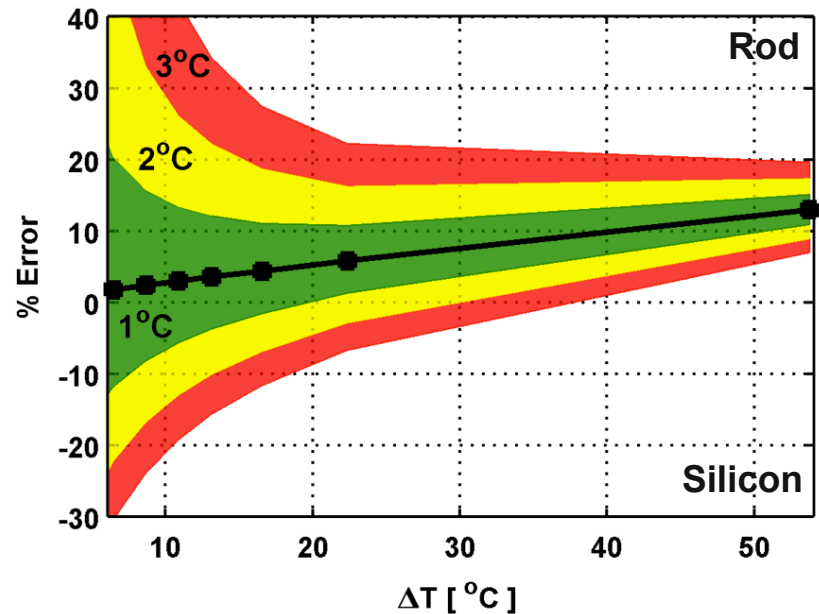
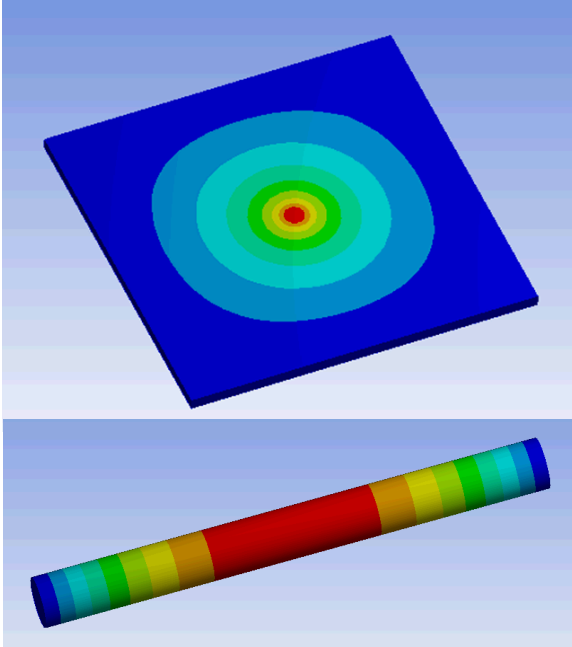
Can we “break” it? Stress



$$\sigma^* = \alpha \left[\frac{\varepsilon}{^\circ C} \right] E \left[\frac{GPa}{\varepsilon} \right] \bullet \frac{B_{Raman} \left[\frac{cm^{-1}}{GPa} \right]}{A_{Raman} \left[\frac{cm^{-1}}{^\circ C} \right]}$$



Takeaways



Bottom Line

Raman is a viable method to measure thermal conductivity.
BUT uncertainty and stress effects require alternative approaches.

Temp. Profile. Larger Uncertainty.

