Thermal Boundary Resistance

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Design Problem

- two different types of mechanical element are needed to conduct the large heat flow generated by absorption of the laser light: *heat-links* and *suspended masses*.
- The thermal resistance across the interface of these two elements is potentially a serious problem.

Bars solved it?

- No, unfortunately
- Heat load from sensors (transducer + SQUID) was microWatts.

Definitions

- Heat current = $\dot{Q}$
- Temperature difference = ΔT
- Thermal Resistance = R
- Thermal Conductance = $G = R^{-1}$
- The connections

$$R = G^{-1} = \frac{\Delta T}{\dot{Q}}$$

Option? Pressed or clamped contacts?

- No, if literature is correct.
- Surface roughness of a pressed interface has almost no contact at the atomic level, and very little heat crosses, for all materials.
  - Reference: section 4.7, "Experimental Techniques in Low Temperature Physics", 4th Ed., by Guy White and Phillip Meeson, Clarendon Press, Oxfore, 2002 [I will add some pages to doc center]

Option: Thin Film deposition

- YES! Proven to have very small boundary resistance.
- Mechanism for heat transfer, transmission of phonons across interface (that has atom-atom-contact over full area).
- Theory and experiment in pretty good agreement

Theory and Experiment for (any) metal film on sapphire

- All metal films deposited on sapphire, with area A, at temperature T, should have R given by

$$RA = (20K^4 \cdot cm^2/W)/T^3$$

Estimate:

- Assume T = 10 K
- And A = 1 mm x 5 mm = 5e-2 cm^2
- So R = 0.4 K/W
- Assume Qdot = 1 W
- => DT = 0.4 K ! Good enough