Annealing Temperature Thermal Conductivity of Superconducting Niobium

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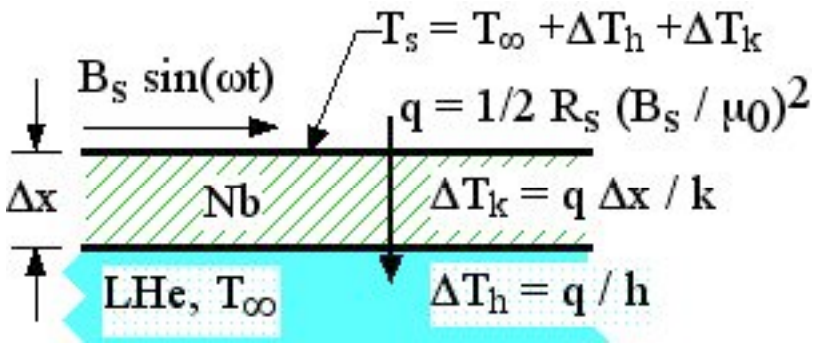
Heat transfer at a cavity wall



Temperature excursions decrease performance

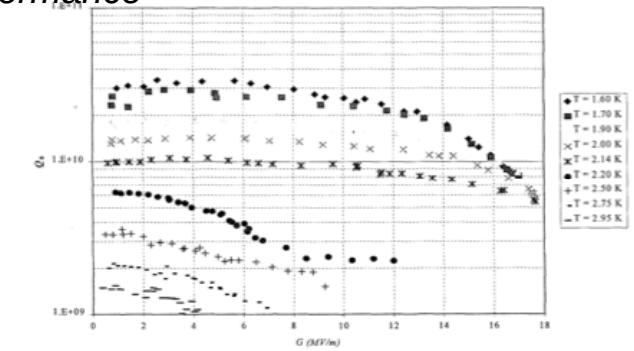
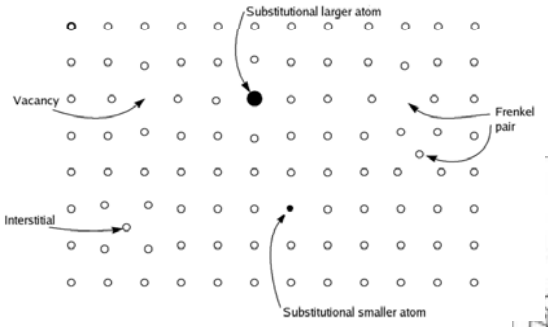
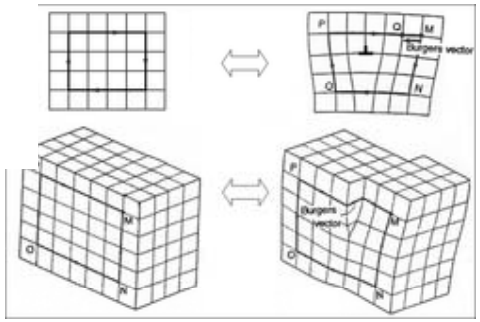


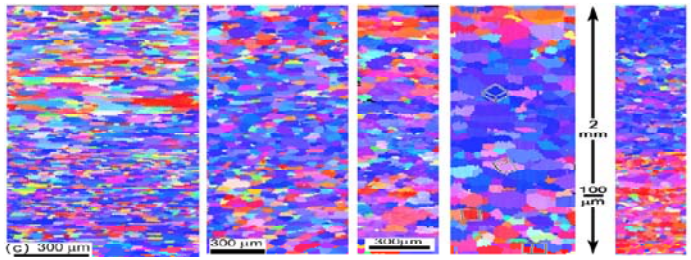
Fig. 1. 7 Cell 1500 MHz Cavity Q_0

Impurities and dislocations can impede conduction heat transfer





High purity Nb commercially rolled can show preferred orientations ({100} near surface and {111} in the interior).

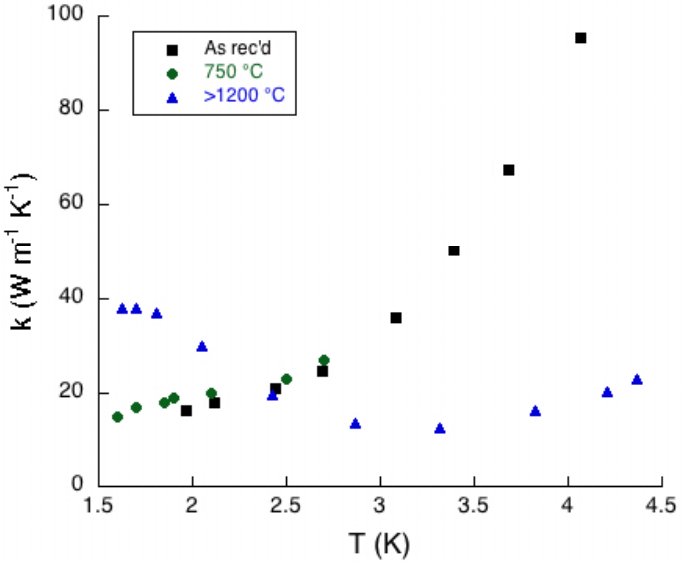


Role of heat treatment on polycrystalline Nb at 4.2 K (Kneisel, 1988)

	k (W m^{-1} K^{-1})				
Material	as rec'd	2 h 2000 °C UHV	6 h 1250 °C Ti	6 h 1250 °C Ti	>10 h 1300 °C Ti
Fansteel	19	11	49	103	160
WahChang				122	150
Heraeus				80	40

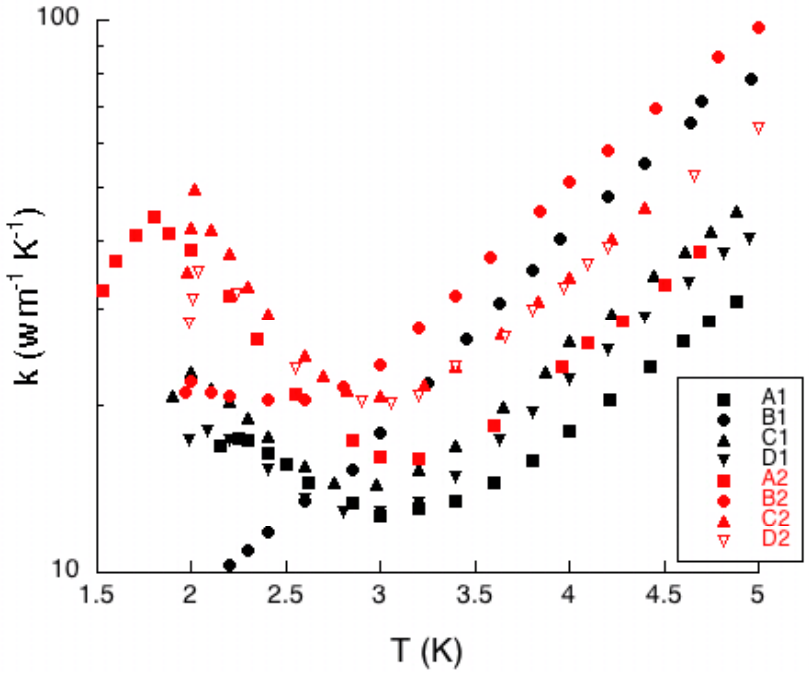
Two heat treatments of polycrystalline Nb (Aizaz, 2006)

- As received material has no phonon peak and RRR> 350.
- 750 °C for 2 h increased k. somewhat, T < 3 K.
- 1300 °C for 2 h & at 1200 °C for 4 h:
  -- phonon peak, with decrease k.

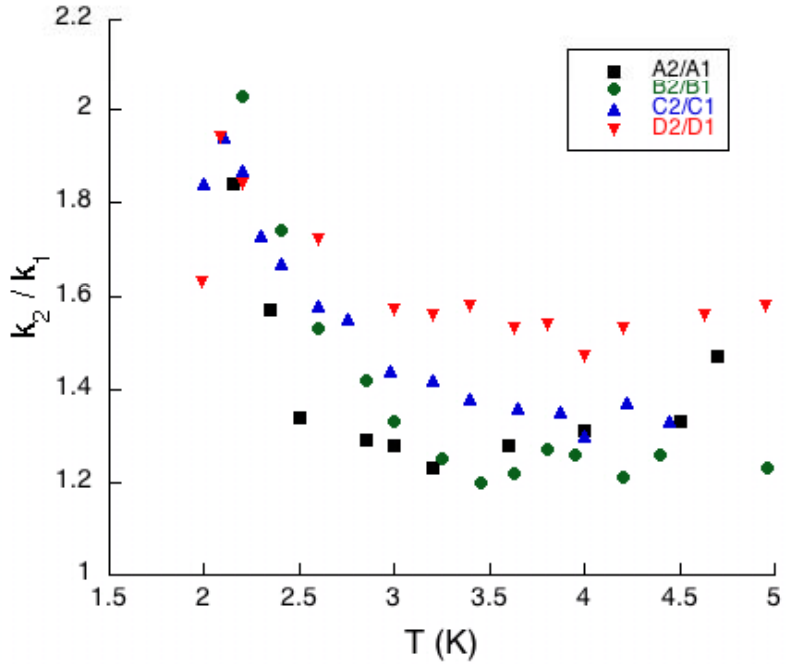


Large Grain Nb (CBMM) *k* Mondal et al.

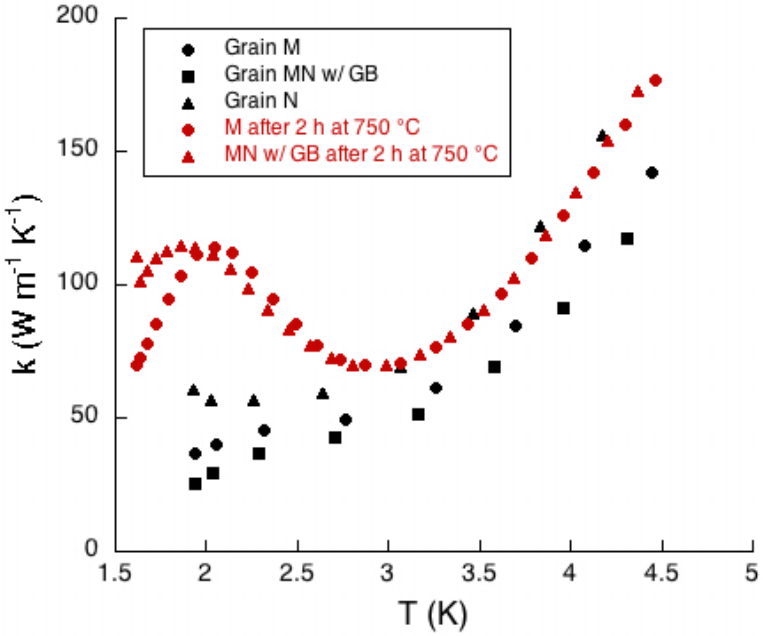
- *Four ingots*
- *As received, after BCP etch (black)*
- *After 10 h at 600 ℃ and 10^{-6} torr and BCP etch (red)*



Ratios of k before and after heat treatment show improvement across the temperature range



Bi-crystal Nb specimens show a similar trend after 2 hr at 750 ℃



Improved thermal conductivity after heat treatments at 600 ℃, 750 ℃, or >1200 ℃

Modeling and parameter estimation to uncover the role of materials processing on the various mechanisms

$$k(T) = R(y)[\frac{\rho_{295K}}{L\Pi T} + aT^2]^{-1} + [\frac{1}{De^{-y}T^2} + \frac{1}{B\lambda T^3}]^{-1}$$

How does this relate to materials processing?
Dislocation density?
Grain orientation?