Experimental characterization of Al – Cu thermal contact resistance below 50 K

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We present the measured thermal resistance of copper-to-copper interfaces with several intermediate contact-enhancing materials as a function of temperature and pressure. Devices such as superconducting coils are increasingly being operated conduction-cooled, with a cryo-cooler acting as a drain for heat loads. The interface with the cooler typically involves at least one clamped connection to a copper cold-head, while often the system's cold bus also relies on several of these links. Unavoidably, each connection introduces extra thermal resistance. If they are not properly designed, the corresponding temperature drops across these interfaces can be significant and may even determine the operational limits of the device.

Proper design hence relies on the availability of a comprehensive database of thermal contact resistance values, measured under well-defined conditions. Although literature data are available for different material combinations and interface types, values strongly depend on parameters that are sometimes poorly described. The contact pressure and its distribution, temperature, material hardness and surface roughness are the main parameters that may influence the value of the thermal contact resistance. In addition, clamped connections are usually not made between bare surfaces, but with thermal grease or indium wire/sheet in-between to improve the effective surface area.

In this paper, the thermal contact resistance of clamped Aluminum-copper connections is measured under steady-state conditions for increasing clamping force, temperature (4.2 K – 50 K) and intermediate material (indium wire, thermal grease and silver-loaded grease). To evaluate the reproducibility, all measurements are repeated several times, each time replacing the copper and aluminum pieces (ETP copper wafers and aluminum RRR 1600) with new ones and quantifying their roughness with a surface profiler. Also possible effects of stress concentration in the bolted clamping connection between two plates is investigated.