Thermal Contact Resistance

Hot Disk AB

Thermal contact resistance is always present in the interface between two solid surfaces. In this example, we look at contact resistance between layers in a stack of copper sheets and its impact on the apparent thermal conductivity across the layers.

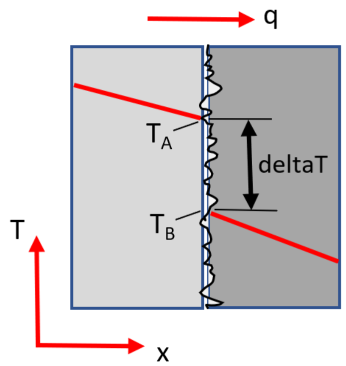

Figure 1a: Temperature drop across boundary region at an interface

Interfaces slow the propagation of heat in a structure. This can be illustrated as a temperature drop across the boundary region, as depicted in Figure 1. As a result, powders have a low apparent thermal conductivity, even if the intrinsic conductivity of the material is high. Contact resistance is important in any structures with a large number of interfaces, eg. laminates, powders, composites etc.

In this application, a stack of polished 0.2 mm thick copper sheets (Figure 2) was tested. The stack was exposed to mechanical pressure in the axial direction. For comparison, measurements were repeated at two different pressures, the higher pressure being more than four times higher than the initial pressure.

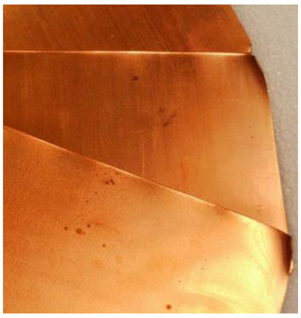

Figure 2: Sample Copper Sheets

The anisotropic measurements performed show that the thermal conductivity in the radial direction (in the plane of the sheets) is in the expected range for bulk copper, just below 400 W/m/K. However, in the direction perpendicular to the sheets, the value is dramatically lower. In the case of 1.8 kPa pressure, the conductivity is 650 times lower in the axial direction, across the interfaces, as compared to the in-plane conductivity. When pressure increases, the conductivity in the direction of the pressure vector rises somewhat, but the anisotropy is still monumental with a 460 times higher conductivity in the plane.

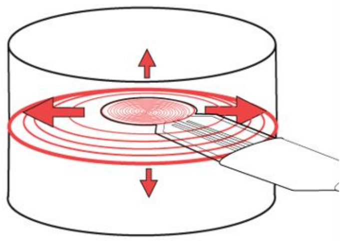

Figure 3: Anisotropic Module Hot Disk

Measurement	λ_{radial} [W/m/K]	λ_{axial} [W/m/K]	κ_{radial} [mm^2/s]	κ_{axial} [mm^2/s]
1	384.6	0.5963	111.8	0.1734
2	388.3	0.5862	112.9	0.1704
3	389.0	0.5884	113.1	0.1710
4	383.7	0.5999	111.5	0.1744
Avg.	386.4	0.5927	112.3	0.1723

Table 1.: Thermal conductivity of copper, stack of 0.2 mm thick sheets, Axial pressure 1.8 kPa.

Measurement	λ_{radial} [W/m/K]	λ_{axial} [W/m/K]	κ_{radial} [mm^2/s]	κ_{axial} [mm^2/s]
1	386.2	0.8483	112.3	0.2466
2	390.1	0.8328	113.4	0.2421
3	385.5	0.8534	112.1	0.2481
4	387.7	0.8458	112.7	0.2459
Avg.	387.4	0.8458	112.6	0.2457

Table 2.: Thermal conductivity of copper, same stack of 0.2 mm thick sheets, Axial pressure 7.5 kPa.

As no medium is present between the layers, the conductivity drop can be attributed to contact resistance. This clearly illustrates the significance of thermal contact resistance between solid surfaces.