Hot Disk ®

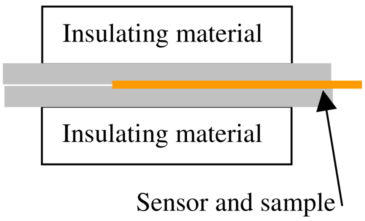
The leader in transient techniques

Slab and Anisotropy measurements on sheets of Transformer Iron Core

The slab module

The slab technique is specially designed for high conducting samples like Copper, Silicon wafers, SiC wafers, and sheets of Graphite to mention a few sample types.

The sample setup consists of a sensor embedded in between two slabs (~0.5 – 5 mm thick). The setup is then insulated with either air, vacuum or Polystyrene forcing the heat to diffuse in the radial direction, see figure below.



Measurement times are usually short (0.5 – 10 s) depending on diffusivity, choice of sensor and size of the sample.

As all other modules available for the Hot Disk Thermal Constants Analyser, the Slab module measures thermal conductivity and diffusivity without the influence from thermal contact resistance.

Introduction

The Hot Disk Thermal Constants Analyser can be used for measurements on anisotropic samples such as stacks of metal sheets. In this application note sheets of transformer iron core samples were measured with both the *slab* technique in order to obtain the individual plate's thermal conductivity, diffusivity and specific heat capacity and the *anisotropic* technique to find the properties of a stack of these plates, see fig. 1.

Experimental & Results

A sensor with radius 6.403 mm (S/N 5501) was used for all measurements (anisotropic and slab). The average sheet thickness was measured to be 0.54 mm. The slab measurements were carried out on 2 individual pieces of the metal. Polystyrene was used as insulator on both sides of the sample-sensor-sample set-up. The following measurement parameters were used: measurement time 5 s and power 0.5 W. This gave a temperature increase of roughly 1.9 ^{o}C and a probing depth around 12.8 mm. The results were as follows:

Thermal Conductivity: 26.55 +/- 0.02 W/mK
Thermal Diffusivity: 7.676 +/- 0.004 mm^2/s
Specific Heat Capacity: 3.459 +/- 0.003 MJ/m^3K

A stack (~2.5 cm high) was then measured with the anisotropic technique, with power 1.5 W and 6.5 s measurement time. The specific heat capacity of the stack was approximately estimated to be 1.5 % lower than the specific heat capacity of the metal sheets themselves due to air gaps. Thus, the estimated specific heat capacity fed to the program was 3.407 MJ/m^3K.

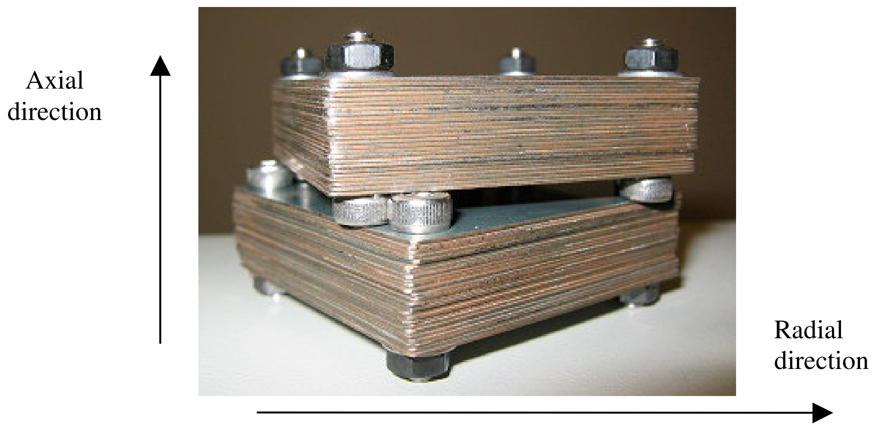


***Fig. 1**. The stack of metal sheets. By removing the screws it was possible to insert a sensor in between the two sample pieces. A slab measurement was carried out on 2 individual sheets. The arrows give the directions in for the anisotropic measurments.*

The measurement results for the anisotropic measurements are given below:

Axial thermal conductivity : 0.75 +/- 0.03 W/mK
Axial thermal diffusivity: 0.219 +/- 0.008 mm^2/s

Radial thermal conductivity: 22.2 +/- 0.6 W/mK
Radial thermal diffusivity: 6.5 +/- 0.2 mm^2/s

Discussion

The axial thermal conductivity and diffusivity is significantly lower than the radial conductivity and diffusivity, mainly because of the air-interfaces between the metal sheets. The thermal conductivity in the radial direction is roughly 16 % lower than the slab measurements indicated. This difference in thermal conductivity is possibly due to the fact that the air layers between the metal sheets decrease the "overall" thermal conductivity in the radial direction.

The anisotropic properties of a sample like this well describes in which directions the heat is transported away from a heat source. It also shows the influence air layers can have on the conductivity and diffusivity. It is very likely for instance that the thermal conductivity in both directions (radial and axial) should be dependent on the pressure applied on the sample set-up.

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