Effect of Silicone-Paste Properties on the Accurate Measurement of the Thermal Conductivity of Solids with the Transient Hot-Wire Technique

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In a set of previous papers [1,2] a novel refined transient hot-wire technique has been implemented to measure the thermal conductivity of solid materials with an absolute uncertainty less than 1 %. In that application in order to minimize the contact resistance between the hot-wire sensor and the solid sample and to attribute elastic properties to the sensor, a soft elastic silicone paste has been used. Measurements at very short times (<0.5 s) were used to evaluate the properties of the paste and at larger times (< 10 s) to evaluate the properties of the solid.

The choice of the silicone paste is of great importance to the realisation of low uncertainty measurements. It needs to have:

- constant thermal conductivity at each temperature over time not only during one measurement but over a cycle of measurements. The thermal conductivity of the paste, defines the type of materials (good or bad thermal conductors) that can be measured within the stated uncertainty.

- high elasticity that is constant over time. The elasticity of the paste should not be affected any curing process during a series of measurements over a range of temperature which takes several days. The elasticity needs to remain high to avoid having thermal contact resistance between the sensor and the samples.

Finally, it should be emphasised that the highest temperature of the measurements is limited by the melting temperature of the silicone paste.

In the current study we investigated the change of the thermal conductivity of the silicone paste over time owing to degradation. This was achieved by using the same sensors built in 2007 and 2008 [1,2] to measure once more the thermal conductivity of reference solid materials Pyrex 7740 and Pyroceram 9660 and of candidate reference materials PMMA and BK7 over the same temperature range (up to 450 K). The finite element method (FEM) is used to evaluate the thermal conductivity of the silicone paste and the solid samples.

References

[1] M.J. Assael, K.D. Antoniadis, K.E. Kakosimos, I.N. Metaxa, Int. J. Thermophys. 29, 445 (2008)

[2] M.J. Assael, K.D. Antoniadis, J. Wu, Int. J. Thermophys. 29, 1257 (2008)