TIM Thermal Conductivity Measurement Issues

TIM thermal conductivity measurements require careful consideration of several factors when establishing the equipment setup and measurement conditions. There is a tendency to pick an arbitrary sample size and heat flux level as the starting point without thought being given to measurement realities. This document addresses the factors that should be considered in addition to sample size and heat flux levels.

First, for any given sample area, a minimum of three thicknesses should be used in order to determine both the Bulk Thermal Conductivity (BTC) of the material and the Bond Line Resistance (BLR) that occur between the sample material and the measurement equipment. The BLR determined is for both sample interfaces. Further discussion of this issue can be found in TB-10 (see http://www.thermengr.net/TechBrief/TB-10.pdf). Based on practical experience, the suggested thicknesses are 0.005” (0.127mm), 0.010” (0.254mm) and 0.015” (0.381mm).

Second, when using the three-thickness approach described in TB-10, thought must be given to the temperature differential (ΔT) across the measurement sample. If the ΔT across the thickest sample is too large compared to the ΔT across the thinnest sample, then there is concern that the BTC sensitivity to temperature might affect the measurement results. On the other hand, the ΔT across the thinnest sample should not be so small as to cause measurement problems of its own. For these reasons, it is usually best to limit the minimum ΔT to ≥1ºC and the maximum ΔT to ≤10ºC.

Third, the maximum thickness of the measurement sample should be limited to some reasonable value so as to not cause heat flux leakage from the measurement platens to the surrounding environment. Heat flux leakage can be determined by comparing the heat flux measured in the top Heat Flux Column (HFC) to that measured in the bottom HFC (see bottom of page one in TIM Measurement System document for HFC configuration). A difference of a few percent is acceptable but 10% or more is not. For this reason, the measurement sample thickness should be limited to not more than about 5mm (≈0.2”).

Fourth, it is always helpful when setting up the measurement conditions to have a rough idea of the BTC. An exact number is not necessary – a range is sufficient.

Fifth, the heat flux level (Q) should be some reasonable value that avoids problems on both the low end and the high end. For example, a Q below 5W is usually not advisable because the time to reach a steady-state measurement condition will be longer and because measurement stability could be problematic. On the other hand, Q values above 100W will significantly increase heat flux leakage and increase the difference in top and both HFC measured values. For these reasons, a Q value in the 5W to 100W are typically used. These values are the setting value for the measurement but the HFC measured values are usually slightly below the setting.

THERMAL ENGINEERING ASSOCIATES, INC.
www.thermengr.com

3287 Kifer Road
Santa Clara, CA 95051
USA

Phone: 650-961-5900
FAX:: 650-323-9237
E-mail: info@thermengr.com

TIM Thermal Conductivity Measurement Issues (cont'd)

Sixth, with all the issues discussed above in hand, the remaining variables are the measurement sample area and the heat flux passing through that area. The equation for the thermal conductivity is

$$K_\theta = \frac{Q \times L}{\Delta T \times A} \qquad (1)$$

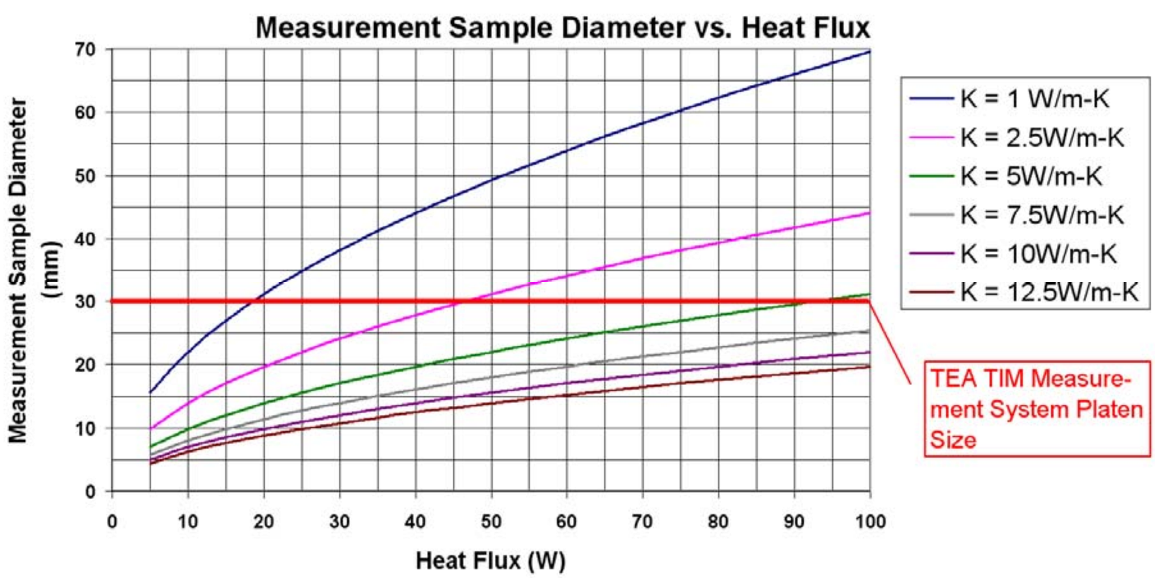
where:

K_θ is the thermal conductivity
ΔT is the temperature differential across the TIM
Q is the heat flux passing through the TIM
L is the thickness of the TIM
A is the TIM area through which Q flows

Rearranging Equation (1) to solve for A and then the measurement sample diameter (D), the equation becomes:

$$A = \frac{Q \times L}{\Delta T \times K_\theta} \qquad (2) \qquad\qquad D = \sqrt{\frac{4 \times Q \times L}{\pi \times \Delta T \times K_\theta}} \qquad (3)$$

Plotting Equation 3 for various values of K_θ, assuming ΔT is 10ºC and L is 0.381mm, produces the graph below.



Using this graph, one can either find a value of D for a given Q or, conversely, a value of Q for a given D for values of K_θ in the 1 to 12.5W/m-K range. Equation 3 should be used for greater K_θ values. Equation 2 should be used for square measurement samples.

The TEA TIM Measurement System has a 30mm diameter sample platen that will accept solid samples to 21mm (≈0.83") square. Grease TIM samples will require optional sample masks for smaller diameters.

THERMAL ENGINEERING ASSOCIATES, INC.
www.thermengr.com
3287 Kifer Road
Santa Clara, CA 95051
USA
Phone: 650-961-5900
FAX:: 650-323-9237
E-mail: info@thermengr.com