KYOTO ELECTRONICS MANUFACTURING CO., LTD.

Application Note
Thermal conductivity measurement of radiation sheet

Field	: Plastic, Rubber
Apparatus	: Quick Thermal Conductivity Meter
Analytical Method	: Hot Wire Method
Standard	:
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1. Scope

A radiation sheet is an excellent sheet in thermal conductivity, and a thermal conductive sheet is also synonymous.
The material has much resin such as silicone, acrylics and polyolefin, and the thermal conductivity is improved by blending ceramic filler (when thinking electrical insulation properties as important) and a metal filler.
Moreover, a radiation sheet has features which are excellent in flexibility, adhesion and fire retardancy in order to put on LSI such as CPU and heat-generating parts, and to connect it to the radiator (heat sink) and the heat radiation body. It is mainly used for many products which are equipped with the high-density board such as notebook personal computers and the mobile devices.
The management of the thermal conductivity is needed in the combination method of filler because it is an excellent sheet in thermal conductivity.

The Quick Thermal Conductivity Meter has an excellent operability and can be measured easy and rapidly. When starting to measure with holding the probe (Figure 1) to the sample surface of uniform temperature, it will be possible to measure in only 60 seconds.

2. Measurement principle

The probe is composed by the hot wire and the thermocouple put straight. The theoretical equation for the temperature versus time is as follows;

$$T_2 - T_1 = \frac{q}{4\pi\lambda}\ln(t_2 - t_1)$$

where λ is the thermal conductivity, q is quantity of heat, T_1 and T_2 are temperature at the instants of time t_1 and t_2. This means that the temperature has a liner characteristic as a function of the logarithmic of the time. (Figure 2)
The slope of this linear line will be large due to the temperature rise quickly for the low thermal conductivity sample. On the other hand, the slope will be small due to the temperature rise slow for the high thermal conductivity.
Therefore the thermal conductivity of sample can be obtained from the slope of the temperature versus the logarithmic of the time.

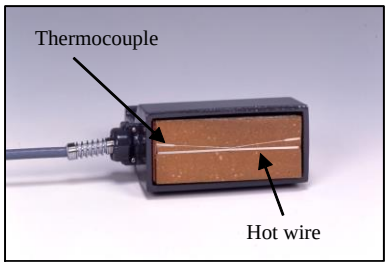

Figure 1. Probe

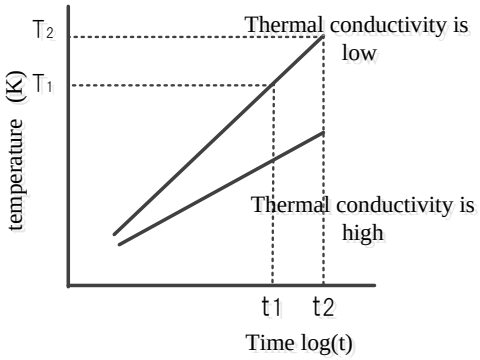

Figure 2. log(t)vsT(℃) graph

3. Precautions

1) The conductivity of sample is confirmed by using multimeter before starting measurement to select the probe.
   Tester is measured at the position separated by about 95mm (equivalent to the heater line of the probe), and the standard probe (PD-11) is selected if the value is 1MΩ or more and the insulated moisture-proof probe (PD-13) is selected if it is smaller than 1MΩ.
2) The heater current value is decided that the temperature rise during measurement may become within 5 ˚C to 20 ˚C. Then the decided heater current value is set from [Heater Screen] of the main unit and the appropriate heater current value has to be selected depending on the sample.
3) The temperature of sample is made almost equal with the environment temperature before starting measurement.

4. Apparatus

Main unit : Quick Thermal Conductivity Meter
Probe : Insulated moisture-proof probe [PD-13] (*1)
*1; Use for the adhesive or wet sample if the sample resistance is smaller than 1MΩ when measuring it with the tester.

The insulated moisture-proof probe is covered with the polyimide film to protect the heater line, the thermocouple, and the base material of the standard probe. The sample that is possible to measure with the standard probe can be measured with the insulated moisture-proof probe too.

5. Measurement condition

The sample is measured with the insulated moisture-proof probe (PD-13) to protect the heater line, the thermocouple, and the base material because it is adhesive.
The heater current value is set that the temperature rise during measurement may become within 5˚C to 20˚C. The temperature rise is small when the heater current is small, so that the error and relative standard deviation become large.
Moreover, the temperature rise becomes 25˚C or more when the heater current is excessive, so that the measurement is stopped.

6. Result

The measurement result of thermal conductivity of radiation sheet is shown as below.
The measurement is performed three times, and a mean value, standard deviation and relative standard deviation are applied.
The radiation sheet can be regarded as cohesiveness even if it is piled up. Therefore, the sample in the state of the block is produced in piles and the measurement is performed only with the Quick Thermal Conductivity Meter. Moreover, the measurement is performed with Hot Disk Thermal Constants Analyser TPS 2500 S to verify data.

－Ambient condition－

Temperature	23 ˚C

－Measurement result－

Both the measurement result of Quick Thermal Conductivity Meter and Hot Disk Thermal Constants Analyser TPS 2500 S are shown in Table 1.

Table 1.The measurement result of thermal conductivity of radiation sheet

Sample	Measurement of radiation sheet					
Apparatus	Quick Thermal Conductivity Meter				Hot Disk Thermal Constants Analyser TPS 2500 S	
Sample thickness(mm)	4 sheets	5 sheets	6 sheets	7 sheets	1 sheet	2 sheets
	8	10	12	14	2	4
Measurement value(W/mK)	1.902 2.107 2.293	2.098 2.202 2.289	2.186 2.232 2.244	2.241 2.239 2.210	2.151 2.102 2.159 2.116 2.107	2.133 2.105 2.139 2.123 2.118
Mean value (W/mK)	2.10	2.20	2.22	2.23	2.13	2.12
Standard deviation (W/mK)	0.1955	0.0957	0.0304	0.0172	0.026	0.013
Relative standard deviation (%)	9.3	4.4	1.4	0.8	1.2	0.6

※φ4 mm sensor is used for TPS 2500 S

7. Summary

The measurement result of the adhesive radiation sheet (2mm in thickness of one sheet) is no difference between Quick Thermal Conductivity Meter and Hot Disk Thermal Constants Analyser.
Normally, the optional Software for thin Sheet Measurement is used for the sheet of 2mm in thickness when measuring it with Quick Thermal Conductivity Meter. However, the adhesive sample like this time can be measured without the optional software when the sample in the state of the block is produced in piles because it can be regarded as cohesiveness even if it is piled up.
This method is applied to uniform materials in principle.