An investigation of the thermal conductivity of epoxy resin systems filled with boron nitride particles

Annex
In the following document all the evaluations that has been made during the TFG are going to be presented.

In this first section the following evaluations are exposed:

- Evaluations from the samples of the dual curing process
- Evaluations of isothermal experiments for the ETLNB80-X system
- Evaluations of dynamic experiments for the ETLNB80-X system
- Evaluations of thermogravimetric experiments for the ETLNB80-X system
- Evaluations of isothermal experiments for the ETLNB80/2-X system
- Evaluations of dynamic experiments for the ETLNB80/2-X system
- Evaluations of thermogravimetric experiments for the ETLNB80/2-X system
- Evaluations of isothermal experiments for the ETLNB80/6-X system
- Evaluations of dynamic experiments for the ETLNB80/6-X system
- Evaluations of thermogravimetric experiments for the ETLNB80/6-X system
Integral: 3902.73 mJ
Normalized: 112.54 Jg⁻¹
Peak: 78.93 °C
Left Limit: 47.16 °C
Right Limit: 97.46 °C
<table>
<thead>
<tr>
<th>Parameter</th>
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<tr>
<td>Integral</td>
<td>3847.07 mJ</td>
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<td>3433.50 mJ</td>
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<td>3656.85 mJ</td>
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<td>102.13 °C</td>
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<td>191.51 °C</td>
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<tr>
<td>Right Limit</td>
<td>102.88 °C</td>
<td>Right Limit</td>
<td>187.06 °C</td>
<td>Right Limit</td>
<td>320.19 °C</td>
</tr>
</tbody>
</table>

**ETL(r=0.25)NB6-30 25/300 10C7min**

**ETL(r=0.25)NB6-30 25/300 10C7min, 43,2200 mg**

Lab: Thermodynamics

STAR® SW 12.00
ETL(r=0.25)NB6-30 25/300 10C/min
ETL(r=0.5)NB6-30 25/300 10C/min, 65,6400 mg

Integral 1760,85 mJ
normalized 26,83 Jg^-1
Peak 83,68 °C
Left Limit 54,32 °C
Right Limit 104,43 °C

Integral 1328,28 mJ
normalized 20,24 Jg^-1
Peak 146,34 °C
Left Limit 103,31 °C
Right Limit 193,88 °C

Integral 1001,79 mJ
normalized 15,26 Jg^-1
Peak 254,46 °C
Left Limit 196,48 °C
Right Limit 317,11 °C
ETL(r=0.5) Cura,25/350 + Scan

Integral: 6015.63 mJ
Normalized: 266.30 J g⁻¹
Peak: 90.52 °C
Left Limit: 58.96 °C
Right Limit: 102.05 °C

Lab: Thermodynamics
ETL(r=0.5)NB6-50 25/300 10C/min
ETL(r=0.5)NB6-50 25/300 10C/min, 27,2800 mg

Integral: 4185.77 mJ
Normalised: 153.44 Jg^-1
Peak: 89.66 °C
Left Limit: 51.34 °C
Right Limit: 111.81 °C

Integral: 1324.06 mJ
Normalised: 48.54 Jg^-1
Peak: 153.96 °C
Left Limit: 111.06 °C
Right Limit: 214.56 °C
ETL(r=0.5)NB6-60 25/300 10C/min
ETL(r=0.5)NB6-60 25/300 10C/min, 14,4800 mg

Integral normalized 1844.87 mJ  Integral normalized 335.31 mJ
Peak 100.07 °C  Peak 154.59 °C
Left Limit 59.89 °C  Left Limit 119.28 °C
Right Limit 120.40 °C  Right Limit 206.14 °C

Lab: Thermodynamics  STAR® SW 12.00
Integral 2419.20 mJ
Normalized 360.54 J g^{-1}
Peak 85.52 °C
Left Limit 41.94 °C
Right Limit 121.73 °C

Lab: Thermodynamics

STAR® SW 12.00
Integral: 1972.71 mJ
Normalized: 359.33 J g⁻¹
Peak: 74.51 °C
Left Limit: 45.67 °C
Right Limit: 97.78 °C

Lab: Thermodynamics

Temp: 06.06.2017 20:47:17

Temperature Range: -65°C to 180°C, 2°C/min, 2°C/SC
ETLN80/6-10-65/200C 10C/min + 2°C

Integral: 666.24 mJ
Normalized: 325.00 J g^-1
Peak: 96.57 °C
Left Limit: 55.84 °C
Right Limit: 126.11 °C
Integral: 525.12 mJ
Normalized: 308.89 J g^-1
Peak: 86.18 °C
Left Limit: 51.76 °C
Right Limit: 111.68 °C

Lab: Thermodynamics
ETLN80/6-30 -65/180C 2C/min + 2°SC, 11,2000 mg

Glass Transition
Onset 52,46 °C
Midpoint 54,65 °C
Left Limit 39,82 °C
Right Limit 72,33 °C

Integral 3532,15 mJ
normalized 315,37 Jg^\text{-1}
Peak 83,84 °C
Left Limit 50,43 °C
Right Limit 115,14 °C

Lab: Thermodynamics

STAR® SW 12.00
Integral: 3228.29 mJ
Normalized: 175.64 Jg^-1
Peak: 13.92 min
Left Limit: 0.00 min
Right Limit: 33.60 min

Integral: 2733.50 mJ
Normalized: 195.53 Jg^-1
Peak: 29.32 min
Left Limit: 0.00 min
Right Limit: 113.69 min

Integral: 3569.25 mJ
Normalized: 175.14 Jg^-1
Peak: 63.42 min
Left Limit: 0.00 min
Right Limit: 136.41 min
ETLN80/6-60 -65/180°C 5°C/min + 2°C

Glass Transition
Onset: 50.08 °C
Midpoint: 53.52 °C
Left Limit: 38.03 °C
Right Limit: 72.46 °C

Integral: 1278.33 mJ
Normalized: 189.38 Jg^-1
Peak: 106.46 °C
Left Limit: 48.62 °C
Right Limit: 142.65 °C

Lab: Thermodynamics
ETLN80/6-60 -65/200 C 10°C/min + 2°C

Glass Transition
Onset: 51.33°C
Midpoint: 54.30°C
Left Limit: 39.13°C
Right Limit: 73.64°C

Integral: 2512.28 mJ
Normalized: 184.59 Jg^-1
Peak: 117.69°C
Left Limit: 46.01°C
Right Limit: 164.58°C

Lab: Thermodynamics

STAR® SW 12.00
ETLN80/6-50 ISO Glass transition

Glass Transition
Onset 46,80 °C  
Midpoint 50,90 °C  
Left Limit 38,15 °C  
Right Limit 67,84 °C

Glass Transition
Onset 49,76 °C  
Midpoint 53,12 °C  
Left Limit 36,56 °C  
Right Limit 72,76 °C

Glass Transition
Onset 49,54 °C  
Midpoint 52,45 °C  
Left Limit 39,98 °C  
Right Limit 68,65 °C

Lab: Thermodynamics
Glass Transition
Onset: 51.12 °C
Midpoint: 53.57 °C
Left Limit: 35.21 °C
Right Limit: 75.24 °C

Integral normalized: 229.03 Jg^-1
Peak: 103.75 °C
Left Limit: 55.64 °C
Right Limit: 149.69 °C
ETLN80/6-30 Glass transition ISO

Glass Transition

Onset 50.45 °C
Midpoint 52.92 °C
Left Limit 44.08 °C
Right Limit 68.05 °C

Onset 49.77 °C
Midpoint 52.55 °C
Left Limit 42.37 °C
Right Limit 65.31 °C

Onset 48.30 °C
Midpoint 51.47 °C
Left Limit 41.00 °C
Right Limit 71.13 °C
TLNB80/2-60 Glass Transition 60+70+80°C

Glass Transition
Onset 41,91 °C
Midpoint 50,06 °C
Left Limit 37,41 °C
Right Limit 73,16 °C

Glass Transition
Onset 44,83 °C
Midpoint 50,60 °C
Left Limit 36,17 °C
Right Limit 78,43 °C

Glass Transition
Onset 47,08 °C
Midpoint 58,70 °C
Left Limit 37,78 °C
Right Limit 72,50 °C

ETLN80/2-60 ISO 80°C/35min + 2°C
ETLN80/2-60 ISO 80°C/35min + 2°C, 10,3200 mg

ETLN80/2-60 ISO 70°C/120min + 2°C
ETLN80/2-60 ISO 70°C/120min + 2°C, 10,9700 mg

ETLN80/2-60 ISO 60°C/200min + 2°C
ETLN80/2-60 ISO 60°C/200min + 2°C, 13,0100 mg
ETLNB80/2-60 2+5+10C/min + 2oSC

\[ \text{ETLNB80/2-60 -65/180C 2C/min + 2oSC, 17,9000 mg} \]

\[ \text{ETLNB80/2-60 -65/180C 5C/min + 2oSC, 12,0500 mg} \]

\[ \text{ETLNB80/2-60 -65/200C 10C/min + 2oSC, 10,9600 mg} \]
ETLN80/2-60 -65/180C 2C/min + 2°C
ETLN80/2-60 -65/180C 2C/min + 2°C, 17,9000 mg

Glass Transition
Onset  52,71 °C
Midpoint  55,31 °C
Left Limit  36,83 °C
Right Limit  81,58 °C

Integral  3416,13 mJ
normalized  190,85 Jg^-1
Peak  98,34 °C
Left Limit  55,36 °C
Right Limit  149,69 °C

Lab: Thermodynamics

STAR® SW 12.00
Glass Transition
Onset: 52.23 °C
Midpoint: 54.81 °C
Left Limit: 31.82 °C
Right Limit: 78.26 °C

Integral: 2233.40 mJ
Normalized: 185.34 Jg^-1
Peak: 112.18 °C
Left Limit: 60.91 °C
Right Limit: 159.97 °C
ETLN80/2-50 Glass Transition 60+70+80°C

Glass Transition
Onset  47.27 °C
Midpoint  51.12 °C
Left Limit  36.71 °C
Right Limit  73.35 °C

Glass Transition
Onset  49.73 °C
Midpoint  53.06 °C
Left Limit  40.97 °C
Right Limit  74.20 °C

Glass Transition
Onset  49.24 °C
Midpoint  52.43 °C
Left Limit  42.69 °C
Right Limit  77.97 °C
Integral normalized 3804.67 mJ
Peak 11.05 min
Left Limit 0.00 min
Right Limit 34.98 min

Integral normalized 2427.34 mJ
Peak 24.78 min
Left Limit 0.00 min
Right Limit 119.16 min

Integral normalized 2232.47 mJ
Peak 57.62 min
Left Limit 0.00 min
Right Limit 139.23 min

ETLN80/2-50 ISO 80C/35min + 2ºSC
ETLN80/2-50 ISO 80C/35min + 2ºSC, 172800 mg

ETLN80/2-50 ISO 70C/120min + 2ºSC
ETLN80/2-50 ISO 70C/120min + 2ºSC, 105400 mg

ETLN80/2-50 ISO 60C/200min + 2ºSC
ETLN80/2-50 ISO 60C/200min + 2ºSC, 100400 mg
**ETLN80-50 -65/180°C 5°C/min + 2°C/SC**

**ETLN80-50 -65/180°C 5°C/min + 2°C/SC, 10,2800 mg**

**Glass Transition**
- **Onset**: 51.41°C
- **Midpoint**: 54.28°C
- **Left Limit**: 35.18°C
- **Right Limit**: 85.82°C

**Integral**: 2353.85 mJ
- **Normalized**: 228.97 J g⁻¹
- **Peak**: 104.54°C
- **Left Limit**: 55.32°C
- **Right Limit**: 154.66°C

Lab: Thermodynamics

STAR® SW 12.00
**Glass Transition**

- **Onset**: 48.25 °C
- **Midpoint**: 53.55 °C
- **Left Limit**: 33.08 °C
- **Right Limit**: 83.92 °C

**Integral**

- 2058.66 mJ
- Normalized 226.72 Jg⁻¹

**Peak**

- 115.92 °C

**Left Limit**

- 56.91 °C

**Right Limit**

- 172.18 °C
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<tr>
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<td>4859.32 mJ</td>
<td>3959.25 mJ</td>
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<td>316.36 Jg^-1</td>
<td>313.73 Jg^-1</td>
<td>317.02 Jg^-1</td>
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<tr>
<td>Peak</td>
<td>5.65 min</td>
<td>12.65 min</td>
<td>29.00 min</td>
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<tr>
<td>Left Limit</td>
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<td>0.00 min</td>
<td>0.00 min</td>
</tr>
<tr>
<td>Right Limit</td>
<td>34.98 min</td>
<td>86.74 min</td>
<td>86.74 min</td>
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<td>ETLNB80/2-30 ISO 80C/35m +2°C, 15,3600 mg</td>
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<td></td>
<td>ETLNB80/2-30 ISO 70C/120m +2°C, 12,6200 mg</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ETLNB80/2-30 ISO 60C/200m +2°C, 12,8900 mg</td>
</tr>
</tbody>
</table>

Lab: Thermodynamics
ETLNB80-10 Glass Transition ISO 60C/200min + 2°C
ETLNB80-10 ISO 60C/200min + 2°C, 13,5500 mg

ETLNB80-10 ISO 70C/120min + 2°C
ETLNB80-10 ISO 70C/120min + 2°C, 14,9900 mg

ETLNB80-10 ISO 80C/35min + 2°C
ETLNB80-10 ISO 80C/35min + 2°C, 16,7700 mg

Glass Transition
Onset 49,81 °C Onset 50,29 °C Onset 49,49 °C
Midpoint 52,78 °C Midpoint 53,37 °C Midpoint 52,72 °C
Left Limit 35,00 °C Left Limit 36,35 °C Left Limit 38,47 °C
Right Limit 78,15 °C Right Limit 73,12 °C Right Limit 72,56 °C
ETLN80-10 ISO 60+70+80C

Integral 6672.44 mJ
  normalized 397.88 Jg^-1
Peak 3.77 min
Left Limit 0.00 min
Right Limit 28.01 min

Integral 5691.60 mJ
  normalized 395.52 Jg^-1
Peak 3.98 min
Left Limit 0.00 min
Right Limit 58.86 min

Integral 5431.46 mJ
  normalized 400.85 Jg^-1
Peak 19.87 min
Left Limit 0.00 min
Right Limit 72.59 min

ETLN80-10 ISO 80C/35min + 2°C
16.7700 mg

ETLN80-10 ISO 70C/120min + 2°C
14.3900 mg

ETLN80-10 ISO 60C/200min + 2°C
13.5500 mg

Lab: Thermodynamics
Glass Transition
Onset: 53.70 °C
Midpoint: 55.78 °C
Left Limit: 38.23 °C
Right Limit: 74.58 °C

Integral: 5651.05 mJ
normalized: 403.07 Jg^-1
Peak: 79.68 °C
Left Limit: 44.72 °C
Right Limit: 120.31 °C

Lab: Thermodynamics
STAR® SW 12.00
ETLN80-10 -65/180C 5C +2°C

Glass Transition
Onset: 52,42 °C
Midpoint: 55,02 °C
Left Limit: 33,98 °C
Right Limit: 77,02 °C

Integral: 6101,74 mJ
Normalized: 403,82 Jg^-1
Peak: 91,26 °C
Left Limit: 49,41 °C
Right Limit: 130,28 °C

Lab: Thermodynamics

STAR® SW 12.00
Glass Transition
Onset: 52.46 °C
Midpoint: 54.66 °C
Left Limit: 37.82 °C
Right Limit: 79.53 °C

Integral: 5080.75 mJ
Normalized: 397.24 Jg⁻¹
Peak: 102.85 °C
Left Limit: 52.92 °C
Right Limit: 157.29 °C
Glass Transition
Onset: -40.56 °C
Midpoint: -38.81 °C
Left Limit: -54.41 °C
Right Limit: -17.70 °C

Integral: 2515.37 mJ
normalized: 227.63 J/g
Peak: 92.28 °C
Left Limit: 47.81 °C
Right Limit: 136.26 °C
Glass Transition
Onset  -39,81 °C
Midpoint -37,71 °C
Left Limit -56,62 °C
Right Limit -6,24 °C

Integral  2127,49 mJ
normalized  220,24 Jg^-1
Peak  105,92 °C
Left Limit  54,48 °C
Right Limit  151,02 °C
Glass Transition
Onset 52,23 °C
Midpoint 54,45 °C
Left Limit 36,09 °C
Right Limit 74,52 °C

Integral 2234,96 mJ
normalized 219,54 Jg^-1
Peak 117,14 °C
Left Limit 57,20 °C
Right Limit 173,66 °C
Glass Transition
Onset: 51.87 °C
Midpoint: 54.79 °C
Left Limit: 29.27 °C
Right Limit: 79.61 °C

Integral: 2774.52 mJ
normalized: 264.24 Jg^-1
Peak: 100.28 °C
Left Limit: 48.88 °C
Right Limit: 144.86 °C

Lab: Thermodynamics
^exo

Curve: \[41\{\text{ETLNB80-30 \ Iso80C/35m + 2\textdegree C}}\]

<table>
<thead>
<tr>
<th>Glass Transition</th>
<th>Glass Transition</th>
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<tbody>
<tr>
<td>Onset</td>
<td>50,01 °C</td>
<td>Onset</td>
</tr>
<tr>
<td>Midpoint</td>
<td>52,61 °C</td>
<td>Midpoint</td>
</tr>
<tr>
<td>Left Limit</td>
<td>33,77 °C</td>
<td>Left Limit</td>
</tr>
<tr>
<td>Right Limit</td>
<td>76,53 °C</td>
<td>Right Limit</td>
</tr>
</tbody>
</table>

Lab: Thermodynamics

\textsuperscript{ST\textsc{Ar}^\textregistered\textsc{ SW} 12.00}
ETLN80-30 -65/180C 5C/min+ 2°C/SC

Glass Transition
Onset  50.07 °C
Midpoint  52.87 °C
Left Limit  37.97 °C
Right Limit  77.41 °C

Integral  3850.54 mJ
normalized  332.52 Jg^-1
Peak  94.26 °C
Left Limit  57.83 °C
Right Limit  135.63 °C

ETLN80-30 -65/180C 5C/min+ 2°C/SC, 11,5800 mg

Glass Transition
Onset  -39.08 °C
Midpoint  -36.88 °C
Left Limit  -52.70 °C
Right Limit  -8.47 °C

Wg^-1

Lab: Thermodynamics
ETLN80-30 -65/180C 2C/min+ 2°SC

Glass Transition
Onset: 52.08 °C
Midpoint: 54.10 °C
Left Limit: 32.66 °C
Right Limit: 80.78 °C

Integral: 3585.33 mJ
Normalized: 333.52 Jg^-1
Peak: 81.47 °C
Left Limit: 48.37 °C
Right Limit: 121.15 °C

Lab: Thermodynamics

STAR® SW 12.00
In the second section the results the evaluations of the thermal conductivity made by Transient Hot Bridge method is shown for:

- ETLNB80-30
- ETLNB80-50
- ETLNB80-60
- ETLNB80/2-30
- ETLNB80/2-50
- ETLNB80/2-60
- ETLNB80/6-30
- ETLNB80/6-50
- ETLNB80/6-60
Different methods and measurement ranges:

- Diamond
- Aluminum, Graphite
- Silicon
- Iron, Steel
- Alumina, Carbon Bricks
- Silicon nitride
- Alumina Silicates
- Porous Ceramics, Refractories
- Concrete, Glass, Fire clay
- Water
- Wood, Polymers, Coal
- Building boards, Oils
- Fiber boards, Fiber Insulations
- Air, Polystyrene, PUR Foams
- Vacuum Isolation
**Measurement principal:**

The Transient Hot Bridge method, which is used to measure the thermal transport properties of materials, is an enhancement of the Hot Wire or the Transient Hot Strip method (DIN EN 993-14, DIN EN 993-15). The measuring methods mentioned are transient, time depended measuring methods. The advantage of these methods compared to stationary methods is a much shorter measuring time, and the thermal diffusivity is measured in parallel to the thermal conductivity.

The most important part of these methods is a strip shaped conductor (Fig 1a), which is used as a heat source and a temperature sensor also: Embedded between two pieces of sample (Fig 1b), the strip emits a constant heat flow during the measurement. This causes its temperature to rise. The temperature rise over time corresponds to the thermal transport properties of the sample.

This simple arrangement has three essential disadvantages for the measurement:

1. During the measurement some amount of heat is lost by the two electrical conductors. This heat loss avoids the theoretical necessary homogeneous temperature distribution over the length of the strip and leads to systematic deviations of the measurement (end-effect).
2. Because of the very low electrical resistance of the strip, it has only a low sensitivity for temperature changes. The output signal is very low.
3. Since the thickness of the Nickel foil used is only 5...10µm, it’s very sensitive for mechanical stress like pulling and turning.

The Quasi-Steady-State (QSS) method is a new developed method for the measurement of thermal conductivity. By combining characteristic advantages of steady-state and transient techniques and concomitantly avoiding the major drawbacks of both these classes of methods, the QSS method is the perfect choice for thermal conductivity analysis in a wide range from below 1 W/(m•K) up to 100 W/(m•K). The most important steps in the development from the Thermal Hot Strip to the Quasi-Steady-State method (QSS) and the main advantages are:

1. By adding a further temperature sensor to the THW or THS setup is generating a differential signal, which is a time-invariant measure of the thermal conductivity of the material under test. This signal is practically unaffected by homogeneous isothermal, adiabatic and convective boundary conditions.
2. No guarded heater is necessary, which has to be adjusted carefully and controlled permanently. So the measurement setup is simplified to the maximum.

3. The combination of transient and steady-state techniques leads to quick and reliable results.

The Hotpoint sensor is a development of the QSS sensor and only about 4.5 mm small. Its size allows measurements of a big variety of applications, with small sample sizes. Due to its small size, side effect can be neglected. As an extension to the measurements of thermal conductivity, with this sensor thermal diffusivity can be measured, too.
Results:

Customer:
Order number:
Sample: AD ETLNB80-30
Sensor type: HTP
Sensor name: G_9161
Comment:
Measurement time: 100 s
Current for T-measurement: 10 mA
Heating power: 50 mW
Drift measurements: 20
Measurements: 4
Delay: 100 s
Maximum temperature: 150 °C

Average results:
Avg. Temperature: 20.3 °C
Avg. Lambda: 0.797415 W/(m·K)
Avg. Alpha: 197774 mm²/s
Avg. Cp: inf mm
Avg. Effusivity: 0.00180341 (W√s)/(m²·K)
Avg. thermal penetration: 2503.03 mm

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>Lambda in W/(m·K)</th>
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<tbody>
<tr>
<td>20.00</td>
<td>0.770814</td>
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<tr>
<td>20.32</td>
<td>0.793706</td>
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<td>20.47</td>
<td>0.807183</td>
</tr>
<tr>
<td>20.57</td>
<td>0.817957</td>
</tr>
</tbody>
</table>
Results:

Customer:
Order number:
Sample: AD ETLNB80-50
Sensor type: HTP
Sensor name: G_9161
Comment:
Measurement time: 100 s
Current for T-measurement: 10 mA
Heating power: 50 mW
Drift measurements: 20
Measurements: 4
Delay: 100 s
Maximum temperature: 150 °C

Average results:
Avg. Temperature: 21.0 °C
Avg. Lambda: 2.21045 W/(m·K)
Avg. Alpha: 165564 mm²/s
Avg. Cp: inf mm
Avg. Effusivity: 0.00545237 (W√s)/(m²·K)
Avg. thermal penetration: 2292.13 mm

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>Lambda in W/(m·K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.79</td>
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<td>21.13</td>
<td>2.24956</td>
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</table>
Results:

Customer:
Order number:
Sample: AD ETLNB80-60
Sensor type: HTP
Sensor name: G_9161
Comment:
Measurement time: 100 s
Current for T-measurement: 10 mA
Heating power: 50 mW
Drift measurements: 20
Measurements: 4
Delay: 100 s
Maximum temperature: 150 °C

Average results:
Avg. Temperature: 21.6 °C
Avg. Lambda: 3.4013 W/(m·K)
Avg. Alpha: 225703 mm²/s
Avg. Cp: inf mm
Avg. Effusivity: 0.00732245 (W√s)/(m²·K)
Avg. thermal penetration: 2653.19 mm

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>Lambda in W/(m·K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>21.74</td>
<td>3.66339</td>
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<td>21.62</td>
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<tr>
<td>21.57</td>
<td>3.2933</td>
</tr>
<tr>
<td>21.53</td>
<td>3.30993</td>
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</table>
Results:

Customer:  
Order number:  
Sample: AD ETLNB80/2-30  
Sensor type: HTP  
Sensor name: G_9161  
Comment:  
Measurement time: 100 s  
Current for T-measurement: 10 mA  
Heating power: 50 mW  
Drift measurements: 20  
Measurements: 4  
Delay: 100 s  
Maximum temperature: 150 °C  

Average results:  
Avg. Temperature: 21.8 °C  
Avg. Lambda: 0.774141 W/(m·K)  
Avg. Alpha: 197324 mm²/s  
Avg. Cp: inf mm  
Avg. Effusivity: 0.00174766 (W√s)/(m²·K)  
Avg. thermal penetration: 2503.11 mm

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>Lambda in W/(m·K)</th>
</tr>
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<tbody>
<tr>
<td>21.56</td>
<td>0.752639</td>
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<td>21.81</td>
<td>0.771082</td>
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<tr>
<td>21.93</td>
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<tr>
<td>21.96</td>
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</table>
Results:

Customer:
Order number:
Sample: AD ETLNB80/2-50
Sensor type: HTP
Sensor name: G_9161
Comment:
Measurement time: 100 s
Current for T-measurement: 10 mA
Heating power: 50 mW
Drift measurements: 20
Measurements: 4
Delay: 100 s
Maximum temperature: 150 °C

Average results:
Avg. Temperature: 22.2 °C
Avg. Lambda: 2.72144 W/(m·K)
Avg. Alpha: 172418 mm²/s
Avg. Cp: inf mm
Avg. Effusivity: 0.00666254 (W√s)/(m²·K)
Avg. thermal penetration: 2326.48 mm

<table>
<thead>
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<th>Temperature in °C</th>
<th>Lambda in W/(m·K)</th>
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<tr>
<td>21.98</td>
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<td>22.27</td>
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<td>22.32</td>
<td>2.85613</td>
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</table>
Results:

Customer:
Order number:
Sample: AD ETLNB80/2-60
Sensor type: HTP
Sensor name: G_9161
Comment:
Measurement time: 100 s
Current for T-measurement: 10 mA
Heating power: 50 mW
Drift measurements: 20
Measurements: 4
Delay: 100 s
Maximum temperature: 150 °C

Average results:

Avg. Temperature: 22.6 °C
Avg. Lambda: 4.01732 W/(m·K)
Avg. Alpha: 420122 mm²/s
Avg. Cp: inf mm
Avg. Effusivity: 0.00672567 (W·s)/(m²·K)
Avg. thermal penetration: 3522.97 mm

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>Lambda in W/(m·K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.77</td>
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Results:

Customer:  
Order number:  
Sample: AD ETLNB80/6-30  
Sensor type: HTP  
Sensor name: G_9161  
Comment:  
Measurement time: 100 s  
Current for T-measurement: 10 mA  
Heating power: 50 mW  
Drift measurements: 20  
Measurements: 4  
Delay: 100 s  
Maximum temperature: 150 °C  

Average results:  
Avg. Temperature: 21.7 °C  
Avg. Lambda: 0.75079 W/(m·K)  
Avg. Alpha: 333115 mm²/s  
Avg. Cp: inf mm  
Avg. Effusivity: 0.00130464 (W√s)/(m²·K)  
Avg. thermal penetration: 3252.51 mm

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>Lambda in W/(m·K)</th>
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<tbody>
<tr>
<td>21.53</td>
<td>0.733952</td>
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<tr>
<td>21.71</td>
<td>0.753008</td>
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<tr>
<td>21.75</td>
<td>0.75795</td>
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<tr>
<td>21.76</td>
<td>0.758251</td>
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</table>
Results:

Customer:
Order number:
Sample: AD ETLNB80/6-50
Sensor type: HTP
Sensor name: G_9161
Comment:
Measurement time: 100 s
Current for T-measurement: 10 mA
Heating power: 50 mW
Drift measurements: 20
Measurements: 4
Delay: 100 s
Maximum temperature: 150 °C

Average results:
Avg. Temperature: 21.6 °C
Avg. Lambda: 2.70675 W/(m·K)
Avg. Alpha: 256000 mm²/s
Avg. Cp: inf mm
Avg. Effusivity: 0.0053542 (W√s)/(m²·K)
Avg. thermal penetration: 2853.57 mm

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>Lambda in W/(m·K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>21.57</td>
<td>2.6767</td>
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<tr>
<td>21.60</td>
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<td>21.64</td>
<td>2.72553</td>
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<tr>
<td>21.63</td>
<td>2.73874</td>
</tr>
</tbody>
</table>
Results:

Customer:
Order number:
Sample: AD ETLNB80/6-60
Sensor type: HTP
Sensor name: G_9161
Comment:
Measurement time: 100 s
Current for T-measurement: 10 mA
Heating power: 50 mW
Drift measurements: 20
Measurements: 4
Delay: 100 s
Maximum temperature: 150 °C

Average results:
Avg. Temperature: 22.2 °C
Avg. Lambda: 4.17151 W/(m·K)
Avg. Alpha: 276356 mm²/s
Avg. Cp: inf mm
Avg. Effusivity: 0.00816322 (W√s)/(m²·K)
Avg. thermal penetration: 2929.95 mm

<table>
<thead>
<tr>
<th>Temperature in °C</th>
<th>Lambda in W/(m·K)</th>
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<tbody>
<tr>
<td>22.36</td>
<td>4.49427</td>
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<td>22.24</td>
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