SIB 52 Thermo

Industrial High-Temperature Thermal Conductivity Measurements
Review

EMRP SIB 52 Thermo

Stakeholder Meeting

NPL, UK

European Metrology Research Programme
Programme of EURAMET

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Overview

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- Industrial techniques for thermal conductivity measurements
  - Steady-state instruments
  - Transient instruments
- Commercial instruments
- Summary

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Steady-state instruments

- measure thermal conductivity in one direction
  - one-directional stationary heat flow assumed
- specimen(s) sandwiched between heat source and heat sink
- simple working equation
- long run times
- large temperature difference across the sample(s)
  - **Guarded Hot Plate (GHP)**
    - absolute method
  - **Heat Flow Meter (HFM)**
    - comparative method

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Transient instruments

- short run times
- complex working equations – evaluation of T history with software
- with contact: heat source (= thermometer) between 2 samples (= heat sinks)
  - **Transient Hot Wire (THW)**
    - simple setup
    - high operating temperature
  - **Transient Plane Source (TPS)**
    - evaluation of th. conductivity and th. diffusivity by an iteration process
- without contact: th. radiation source; measure T on rear side of the sample
  - **Laser/Xenon Flash (LFA, XFA)**
    - broad working temperature range
    - limited to very small and homogeneous samples

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Commercial instruments

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Manufacturer ***Type***	**Technique**	**Meas. Range** $W \cdot m^{-1} \cdot K^{-1}$	**Max. Temp.** **°C**	**Accuracy/** **Uncertainty**	**Sample dim.**
Hotdisk AB TPS series (mica sensor)	TPS	0.005 – 1800	1000	< 5 %	min. ⌀ 13 × 3 mm^2
Laser Comp FOX 300 HT GHP 600	HFM GHP	0.1 – 10 0.1 – 10	250 250	> 1 % (40 °C)	≤ ⌀ 51 mm
Linseis Messgeräte GmbH XFA 500 LFA 1000	XFA LFA	0.1 – 2000 0.1 – 2000	500 1600	nn nn	both instruments: (a) ≤ ⌀ 25.4 × 6 mm^2 (b) 10 × 10 × 6 mm^3
Netzsch Thermal Analysis Titan 456 LFA 427/457 LFA 447/467 TCT 426	GHP LFA XFA THW	0.005 – 20 0.1 – 2000 0.1 – 2000 < 2	250 ≤ 2800 ≤ 500 1250 (1500)	< 2 % nn nn nn	300 × 300 × ≤100 mm^3 all LFA/XFAs: (a) ≤ ⌀ 12.7 × 6 mm^2 (b) 10 × 10 × 6 mm^3 250 × 125 × 75 mm^3
Taurus TLP 500 HT	GHP	0.01 – 0.5	400 (500)	nn	250 × 250 mm^2 500 × 500 mm^2
TA Instruments DTC 300 DXF and DLF series	HFM LFA	0.1 – 40 0.1 – 2000	300 ≤ 2800	3 % - 8 % 5 %	⌀ 50 × 25.4 mm^2 ≤ ⌀ 25.4 × 6 mm^2
Ulvac Riko GH series TC 9000	HFM LFA	0.1 – 15 nn	280 1500	nn 5 % (th. diffusivity)	⌀ 50 × 20 mm^2 ⌀ 10 × 3 mm^2

Features as specified by the instrument manufacturers' websites.

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Summary

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- many instruments commercially available for
  - thermal conductivity $0.01 \le \lambda \le 7\ \mathrm{W \cdot m^{-1} \cdot K^{-1}}$
  - temperatures $10 \le T \le 70$ °C
- no instrument commercially available that fits all requirements
  - high temperatures (at least 800 °C)
  - low thermal conductivity ($0.02\ \mathrm{W \cdot m^{-1} \cdot K^{-1}}$)
  - not limited to very small samples
  - small measurement uncertainty
- usage of self-made HT-instruments

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