Deutsches Zentrum
DLR für Luft- und Raumfahrt

Handout

Laser flash apparatus (LFA)

Measured values
- Thermal diffusivity
- Heat capacity
- Thermal conductivity
- Linear thermal expansion

Description of facility
The Institute of Materials Research runs a comfortable measuring facilities in the field of thermophysical material properties (thermal diffusivity, heat capacity, thermal conductivity, linear thermal expansion). Furthermore, differential thermal analysis and thermogravimetry are available.
The laser flash method is applied to in-house material development but also offered, as a service to many external customers (industrial and institutes). Though a reliable and convenient measurement technique it is not widespread because of high apparatus cost. The laser flash method provides determination of the thermal diffusivity for homogenous materials as well as for coatings on known substrates using small disc-shaped specimens. Covering an application range from room temperature up to 1450 °C it fulfils the needs of thermal characterisation for almost any material and system problem (including ceramic thermal barrier coatings, thermoelectric sensor and generator materials).

Measuring principle

The base face of a cylindrical specimen is heated by a short laser pulse. The succeeding temperature rise at the backside of the specimen is detected by an infrared sensor. The temperature rise forms a smeared step function over time followed by a slightly falling plateau. Solving Fourier's heat conduction equation presuming adiabatic conditions, and taking into account thermal expansion of the sample and infinitesimal heating time, the thermal diffusivity is related inversely proportional to the rise time of the step function to half maximum (and proportional to the square of specimen thickness). Additionally, under real conditions low heat loss over the sample holder and from radiation as well as the finite duration of the stimulating laser pulse signal have to be taken into consideration for evaluation.

Analytic and numeric corrections are applied to account for these deviations from the ideal case. Thermal conduction by radiation within the sample material is not considered, thus the specimen must not be transparent in the infrared.
The apparatus operated at DLR (LFA 427, Netzsch Gerätebau, Selb, Germany) accomplishes automatic control and evaluation of the measurement of thermal diffusivity taking into account all mentioned corrections. The integrated power laser (max. 30 kW, 20 J) of 1064 nm wave length emits nearly trapezoid pulses of adjustable duration between 0,3 and 1,2 ms. The measurement range of the apparatus is as wide as 0.001–3 cm2/s thus almost completely covering the field of any kind of material.

In a temperature range up to 1450 °C measurements can be accomplished under dynamic or static inert atmosphere or vacuum. Only at few laboratories in Germany offer similar methods.

The absolute accuracy of the LFA method is about 3%; the random uncertainty (reproducibility) amounts to 1–2% with three individual measurements taken per temperature point.

Functioning of the facility has been continuously improved in its hardware and methodology. An upgrade of

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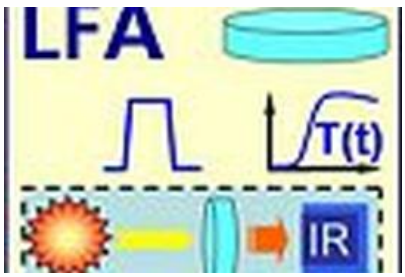

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electronic components and evaluation software to provide the highest available level of computer-assisted measurement is in the planning.

Application
Measurement of thermal diffusivity

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This handout, and cross-references to related measurement techiques and facilities are available at: http://messtec.dlr.de/link-258-en.

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