

# Laser Flash

## Measurement Equipment

Netzsch LFA 467 HyperFlash

- Non-destructive, non-contact method that uses a xenon light source as source of heat
- Measures thermal diffusivity and heat capacity to calculate thermal conductivity
- Requires sample density as input
- Suitable for samples with thermal conductivity between 0.1 - 4000 W/mK
- Assumes homogeneous sample, i.e. fillers must be << than sample thickness

## Sample Specifications

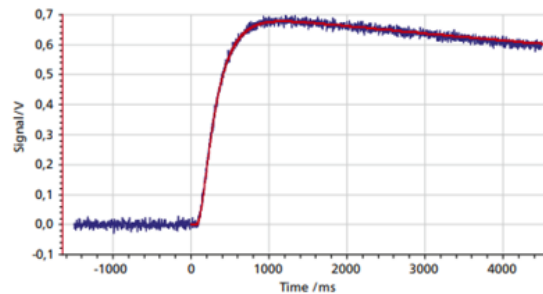
Thickness: > 250 microns, ideally 1 - 5 mm

Size: 10x10 mm (can accommodate other sample sizes upon request)

Samples will be coated with graphite prior to testing to maximize absorption of light pulse

## Details of Method

In the laser flash method, a sample at temperature  $T_0$  is slightly heated by a short incident pulse of radiation on its front side. The temperature of the back side is measured optically and recorded as a function of time from the pulse as shown in the figure below.



When using ZoomOptics, the measurement signal no longer exhibits any distortion caused by the aperture stop

In order to fit the temperature profile above and find the thermal diffusivity, the 2D heat equation needs to be solved following the derivation by Cape and Lehman (*J Appl Phys*, 1963). This is the "standard" model the Netzsch instrument uses to calculate the heat diffusivity, though other models are available in the software.

$$-\nabla^2 T(x,r,t) + \alpha^{-1} \dot{T}(x,r,t) = k^{-1} q(x,r,t)$$

Where  $T$  is the temperature,  $x$  is the azimuthal position,  $r$  is the radial position,  $t$  is time,  $\alpha$  is the thermal diffusivity,  $k$  is the thermal conductivity, and  $q$  is the energy/area of the pulse. As heat loss occurs during the test from radiation, the boundary conditions can be found from the Stefan-Boltzmann radiation law. The initial pulse is assumed to be absorbed in a very thin layer at the surface of the specimen. The pulse is also assumed to be much shorter than the characteristic time required for the heat pulse to propagate the length of the specimen. From here, the temperature increase of the backside,  $a$ , ( $x=a, r, t$ ) can be solved

$$(k/q_0)\delta(a,r,t) = D_0(r,Y_r) \sum_{m=0}^{\infty} C_m X_m e^{\omega_0 m t / t_c}$$

where the characteristic exponent  $t_c$  is proportional to the thermal diffusivity, .

$$t_c \text{ is } (a/\pi)^2 \alpha^{-1}$$

For a full derivation of the solution to the 2D heat equation and the meaning to the Fourier transform terms above, see Cape & Lehman, *J Appl Phys*, 1963.

The heat capacity ( $C_p$ ) is given as

$$DC = Q/LT_m,$$

where  $T_m$  is the maximum temperature the backside of the sample reaches,  $D$  the density,  $L$  the part thickness, and  $Q$  the amount of energy absorbed in the front surface. In order to calculate the incident absorbed energy, a pyroceramic standard with known heat capacity is run prior to the sample of interest.