Unveiling Front Surface Dynamics in Laser Flash Analysis: Modeling and Fitting for Enhanced Thermophysical Insights

Amir Narymany Shandy[1, S, C], Matthias Zipf[1], Frank Hemberger[2], Jochen Manara[2], Thomas Stark[2] and Jürgen Hartmann[3]

[1]*Institute of Zero Carbon, Technical University of Applied Sciences Würzburg-Schweinfurt, Würzburg, Germany*
[2]*Advanced Thermal Management, Center for Applied Energy Research, Würzburg, Germany*
[3]*Institute of Zero Carbon, Technical University of Applied Sciences Würzburg-Schweinfurt, Schweinfurt, Germany*
amir.shandy@thws.de

Laser flash analysis (LFA) has established itself as an extremely useful method for determining the thermal diffusivity of materials. In order to extend the measurement range of LFA, the investigation of the temperature development on the front side comes into focus. To overcome this challenge, an adiabatic front surface temperature model is applied. This model provides a basic approximation of the temperature curves on the front side of the sample.

In order to take into account the high dynamics of the front side temperature evolution due to the heating pulse of the laser, the curve for the adiabatic state is convolved with the shape of a non-Dirac laser pulse. This convolution enables a detailed investigation of the effects of different laser pulse shapes on the temperature evolution on the front side. Not only the maximum temperature is considered, but also the temperature development as a function of time. The choice of the appropriate laser pulse shape is here a critical aspect, as this has a significant influence on the response temperature signal of the front surface (see Fig. 1).

In order to solve the convolution of the adiabatic front-surface curve with a laser pulse shape, two different methods are compared with each other. A numerical solution is obtained by multiplication in the Fourier space using FFT (Fast Fourier Transform) with back transformation, while an analytical solution is obtained using the convolution integral. Both methods are compared in detail with the result of a numerical simulation of the front-side data of a graphite sample and tested for their robustness and applicability.

To further validate the precision and applicability of the developed analytical model, real data measured on the front surface of a graphite sample are fitted with the model. The fit result for the thermal diffusivity is compared with the result obtained by evaluation of the backside temperature development using a standard Laser flash evaluation model to test the suitability of the analytical models as a fit model.

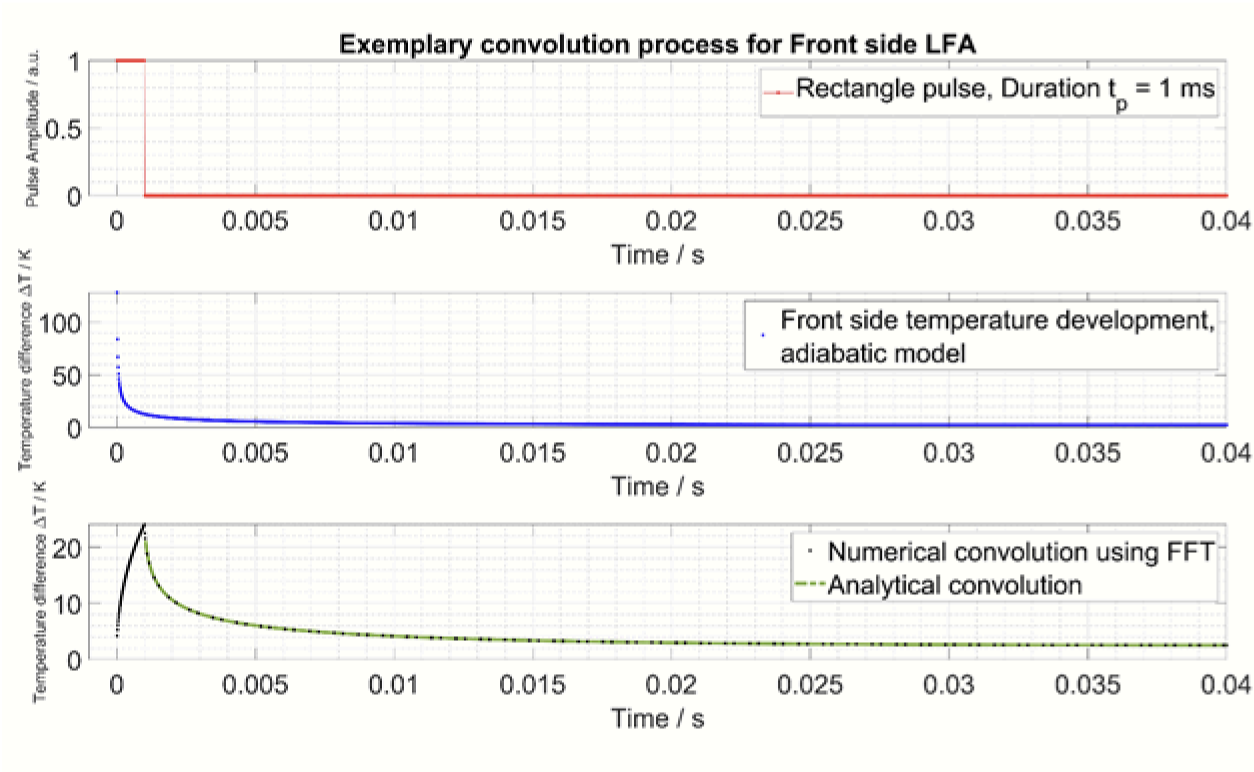

Figure 1: The laser pulse in red is convolved with the front side temperature development curve in blue using numerical and analytical approaches. The results are displayed in black and green for the numerical and analytical solution with matching curves.