Thermal Diffusivity of Materials by Imaging of Lateral Thermal Diffusion

G. Kalogiannakis
Dept. Mechanics of Materials and Constructions, Vrije Universiteit Brussel, Belgium

A. Okasha
Aly Okasha, Spectroscopy Department, Branch of Physics, National Research Center, Dokky, Cairo, Egypt

S. Longuemart and D. Van Hemelrijck
Université du Littoral Côte d'Opale, Laboratoire de Thermophysique de la Matière Condensée (LTPMC), Dunkerque, France

C. Glorieux[C,S]
Departement Fysica en Sterrenkunde, Laboratorium Akoestiek en Thermische Fysica, Leuven, Belgium
christ.glorieux@fys.kuleuven.be

Many of the recently developed photothermal techniques used to determine the thermal diffusivity of materials, such as the flash method [1], are based on the evaluation of the temperature field at a material surface, which is induced by diffused light induced heat generated at the opposite surface. This requires that the sample thickness is on the order of the thermal diffusion length. In practice, though, it is not always possible or desirable to shape the sample in such a geometry. As an alternative, for a thermally thick sample, lateral heat diffusion can be monitored on one accessible surface. Lateral heat diffusion can be excited by illuminating the material with a non-uniform modulated laser light pattern. The detection of the resulting temperature field at the sample surface can be performed by an IR camera.

In this paper, we present a feasibility study of determining the thermal diffusivity of isotropic and anisotropic materials using different excitation patterns. A sinusoidally modulated laser beam was used as a heat source. In a first approach, the laser beam was focused to a Gaussian spot on the sample. In a second one, the laser beam pattern was a spatially periodic grating pattern. Similar to NDT techniques, an IR camera (CEDIP) was used to detect the temporal and spatial dependence of the temperature field. To simplify the ill-posed problem of the thermal properties determination, we have also verified the theoretical predictions concerning the transformation of signal dependencies from 2D to 1D when the temperature field of a 2D configuration is integrated along a direction. This strategy is useful for anisotropic samples, in order to reduce the number of material parameters influencing the signals, and thus to improve the fitting accuracy.

[1] J.C. Krapez, L. Spagnolo, M. Friess, H.P. Maier, G. Neuer, *International Journal of Thermal Sciences* **43**, 967, (2004).
[2] X. Maldague, *Nondestructive Evaluation of Materials by Infrared Thermography*, London, Springer-Verlag, p. 224, 1993 (new revised edition, John Wiley & Sons Pub., exp. in 2001).