Front detection laser-spot active infrared thermography for thermal characterisation of insulating solids

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Infrared thermography is a useful tool for thermal characterization of materials in a non-destructive way. The parameter usually determined by this technique is the thermal diffusivity. Recently, the usefulness of laser-spot active lock-in infrared thermography technique to also recover the thermal conductivity of bad thermal conductors, taking advantage of the heat losses by conduction from the sample to the surrounding air [1]. The experimental results presented in the mentioned paper were taken using a rear detection configuration. In this work, we show the usefulness of the front detection configuration for the same purpose. The experimental set-up is shown schematically in Fig. 1.

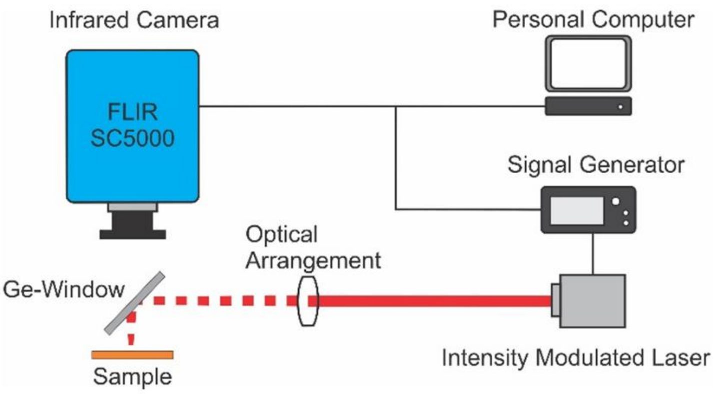
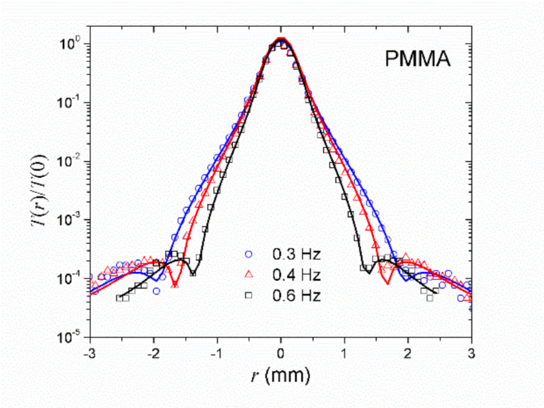
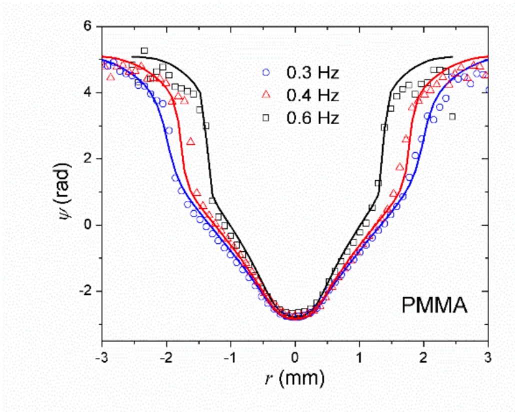


Fig. 1. Schema of the experimental setup. The laser intensity was periodically modulated at a given frequency using a signal-generator. The laser spot size and a mean power at the sample's position were 300 µm (radius) and 10 mW, respectively. A Ge-window was used as a mirror to steer the laser beam to the sample, allowing the heat radiated by the sample to be pictured by the IR camera (Spatial Resolution of 89.5 µm at 100 images/s. Working distance: 17 cm).

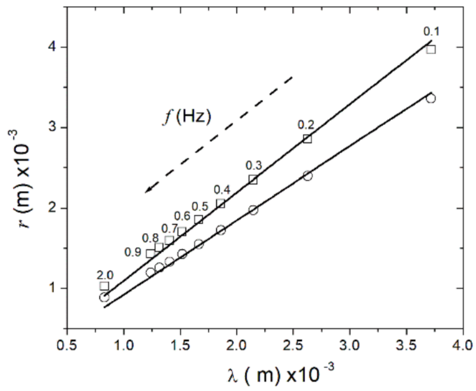
A surface thermogram is recorded at the modulation frequency using a thermographic video camera equipped with a Lock-in amplifier unit, from which amplitude and phase profiles are obtained as a function of the radial distance from the heating spot point. Then, the values of the two mentioned thermal properties are accurately determined by a simultaneous multiparametric fit of the amplitude and phase profiles to the analytical expression describing the temperature field. We show the appearance of maxima and minima in the amplitude profiles at distances from the heating point that are closely related to the thermal wavelength, a behavior that reminds us of interference conditions like those that have been used in a common way to explain other photothermal phenomena [2]. Several samples were studied. Fig. 2 shows a typical result obtained for Polymethyl methacrylate (PMMA). The possibility of using the method for recovering the components of the in-plane thermal properties' tensor in anisotropic samples is discussed too.



(a)



b)



c)

Fig. 1. Normalized amplitude **(a)** and phase **(b)** as a function of the radial distance from the heating point at three modulation frequencies for a PMMA sample. The symbols are the experimental data points, and the solid curves are the results of the best least squares fits using the expression given by the theoretical model described in Ref. [1]. The obtained values of thermal conductivity and diffusivity were $(1.06 \pm 0.02) \times 10^{-7}$ $m^2 s^{-1}$ and (0.20 ± 0.01) W m^{-1} K^{-1}, respectively, in good agreement with literature reported ones. **c)** The positions of the maxima (squares) and minima (circles) of the amplitude versus r curves as a function of the thermal wavelength in the sample for PMMA. The solid curves are the best least squares linear fits with slopes 1.09 ± 0.01 and 1.85 ± 0.02.

References

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