Double and multiple pump pulse time-domain thermoreflectance measurements

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Measurements of the thermal conductivity of thin layers can be performed using techniques such as photothermal radiometry [1], the 3-omega method [2], frequency domain thermoreflectance (FDTR) measurements [3] and time-domain thermoreflectance (TDTR) measurements [4]. TDTR measurements are performed with femtosecond lasers and thus have the potential to measure heat transport across the thinnest layers which take place on fast times scales. In the frequency-domain short times scales correspond to high frequencies. The diffusion length (or penetration) depth of the thermal waves in FDTR is proportional to the square root of the inverse modulation frequency. For maximum sensitivity the diffusion length should be on the order of the length of the layer. FDTR thus has an advantage since the modulation frequency can be adjusted to maximise sensitivity. However for TDTR measurements, a wide frequency bandwidth is present.

In this contribution we numerically investigate double and multiple pump TDTR measurements. Double pump femtosecond pulses can be produced with a single beam splitter while multiple femtosecond pulses can be produced using femtosecond pulse shaping techniques [5]. If the time delay between two consecutive femtosecond pulses is varied, the composite spectrum of any system response will also be varied [6]. For thin layers the sensitivity of thermal conductivity measured with double and multiple femtosecond laser pulses is compared with traditional single pump-pulse TDTR measurements.

References

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