Pulsed laser pump-probe thermoreflectance method for thermophysical properties measurement

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Background: Pulsed laser pump-probe thermoreflectance method provides an alternative way for measurement of the thermophysical properties at extreme conditions,[1] i.e., cross-plane thermophysical properties of thin film, ultrafast dynamic heat transfer process and thermophysical properties at high pressures. In addition, the short pulse laser processing is widely applied and the cut is clean, smooth and without burn. However, the underlying mechanism is still an open question.

Principle: The pulsed laser pump-probe thermoreflectance method is based on temperature-dependent reflectance of sample[2]. When the temperature of the sample changes, the corresponding thermoreflectance will change and there is a linear relationship between the reflectance and the temperature for most metals.

In the method, the pump pulse heats the sample and consequently creates a transient thermoreflectance occurring. The probe beam passes through an optical delay line that is used to increase the optical path length and therefore the delay time with respect to the pump pulse. By changing the time delay, a time resolved cooling file of the sample will be obtained and the corresponding thermophysical properties of the sample and the materials surrounding of the sample can be extracted.

Application example[3]: The electron-phonon relaxation of several polycrystalline thin gold films with different thickness has been investigated using the pump-probe thermoreflectance method. The measurement illustrates that the pump-probe thermoreflectance method is competent for ultrafast measurement. And the results show that the electron-phonon relaxation is nearly the same as that of bulk gold and independent of film thickness, while the electrical resistivity greatly increases compared to the bulk value and tends to decrease as films become thicker. These discrepancies indicate quite a different influence of size effects on electron-phonon relaxation and electrical resistivity of polycrystalline thin gold films.

[1]B. Chen, W. P. Hsieh, D. G. Cahill, et al., *Phys. Rev. B* 83, 13201 (2011).
[2] A. Schmidt, M. Chiesa, X. Y. Chen et al., *Rev. Sci. Instrum*. 79, 064902 (2008).
[3] W. G. Ma, H. D. Wang, X. Zhang, et al., *J. Appl. Phys*. 108, 064308 (2010).