Laser Flash Raman Spectroscopy Method for Thermophysical Characterization of Nanomaterials

Yudong Hu, Jinhui Liu and Xing Zhang [C, S]
Department of Engineering Mechanics, Tsinghua University, Beijing, China
x-zhang@mail.tsinghua.edu.cn

Recently, a noncontact technique based on the temperature dependent Raman band shift has been applied for thermophysical characterization of low dimensional nanomaterials. However, in most measurements the laser absorptivity requires to be determined beforehand and the difficulty of accurately determining the laser absorptivity significantly limits the accuracy of this Raman technique. In general, to avoid the direct measurement of the laser absorptivity, a direct current is supplied to eliminate the laser absorptivity in theory, making the experiment more difficult and samples at a risk of burnout. To solve these problems, in this work, a transient "laser flash Raman spectroscopy" method is presented to characterize the thermal properties of low dimensional nanomaterials, with which the laser absorptivity can be easily eliminated and the electricity is needless. The measuring method for the thermal diffusivity and thermal conductivity of individual micro/nano wires is first presented. In this method, a focused short pulsed laser and a continuous-wave (CW) laser in a Raman spectroscopy system are served as a local heater, Raman signal excitation source and also a temperature sensor. Transient and steady-state heat conduction models are established to obtain two independent equations for the thermal diffusivity and laser absorptivity. This new method has been verified by comparing experimental results of a graphite carbon fiber with measurements employing the 3ω method. Further, the method is used to measure the temperature dependent thermal diffusivity and thermal conductivity of individual carbon nanotubes (CNTs), which fit well with theoretical trends. The present transient method has further been extended to 2D nanomaterials. By using a transient heat conduction model in cylindrical coordinate, the thermophysical properties can be determined by fitting the curves of the normalized temperature rise versus the laser pulse width for various laser spot radii. The uncertainty caused by temperature measurement is analyzed theoretically and through a case analysis of silicon nanofilm, changing laser spot radii is proved to be more easily in practical use than changing laser pulse width.