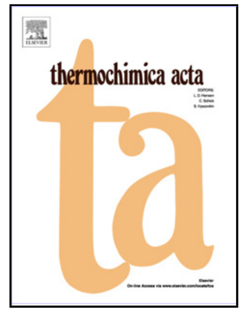
Accepted Manuscript



Title: Characterization of thermal transport and laser absorption properties of an individual graphitized carbon fiber by applying Raman thermography

Authors: Jinhui Liu, Yudong Hu, Xing Zhang

PII: S0040-6031(18)30060-1
DOI: https://doi.org/10.1016/j.tca.2018.03.001
Reference: TCA 77951

To appear in: *Thermochimica Acta*

Received date: 24-10-2017
Revised date: 15-2-2018
Accepted date: 5-3-2018

Characterization of thermal transport and laser absorption properties of an individual graphitized carbon fiber by applying Raman thermography

Jinhui Liu[a,c,*], Yudong Hu[b], Xing Zhang[b,*]

[a]School of Energy and Power Engineering, Nanjing University of Science and Technology, Nanjing, Jiangsu 210094, China

[b]Key Laboratory for Thermal Science and Power Engineering of Ministry of Education, Department of Engineering Mechanics, Tsinghua University, Beijing 100084, China

[c]MIIT Key Laboratory of Thermal Control of Electronic Equipment, School of Energy and Power Engineering, Nanjing University of Science and Technology, Nanjing, Jiangsu 210094, China

ABSTRACT

Graphitized carbon fibers have potential applications owing to their excellent electrical, mechanical, thermal and optical properties. Thermal transport and laser absorption properties are the fundamental parameters for the thermal design, but difficult for determining due to their very small characteristic sizes. In this study, we systematically investigated the temperature (T)-dependent apparent thermal conductivity (λ_a), thermal conductivity (λ), thermal contact resistance (R_c, between sample and heat sink) and laser absorptivity (α) of an individual graphitized carbon fiber using a non-contact Raman method. This method and the experimental system were verified by comparing the measured thermal conductivity of a 10.0 μm diameter platinum wire with the standard data. The measured λ of this graphitized carbon fiber decreases from 372.4 to 330.1 W/(m·K) as T increases from 338 to 496 K, indicating the three-phonon Umklapp scattering rate increases with temperature. R_c increases with T from 3.44×10^3 to 6.35×10^3 K/W in this experimental temperature range, and the laser (488 nm wavelength) absorptivity is determined to be 0.90±0.02.

Keywords: Raman spectroscopy, Non-contact measurement, Graphitized carbon fiber, Thermal conductivity, Thermal contact resistance, Laser absorptivity

1. Introduction

Miniaturization of electronic devices have greatly improved the performance and reduced the costs [1-3]. Problems arise, however, the greatly decreasing of characteristic size and increasing of power consumption yielded an unprecedented high level of generated heat fluxes [4,5]. At this stage, high temperature and high heat fluxes are at the forefront hindering micro-electro-mechanical systems (MEMS) progress [6-8]. Thermal transport properties of micro/nano devices are important parameters for their thermal design and thermal management. Besides, the optical antenna effects of micro/nano wires are designed to increase the photovoltaic and photothermal conversion efficient [9,10]. In recent years, several original measurement methods for determining thermal transport properties or optical absorption properties of micro/nano wires had been presented [11-15]. However, the integrative characterization of thermal conductivity, thermal contact resistance and laser absorptivity for individual micro/nano wire is challenge.

Raman spectroscopy is a powerful tool for structure characterization and temperature measurement [16,17], which has been applied in the local temperature measurement for carbon [18-24], silicon [25,26] and germanium [27] based crystalized materials. In graphite structures, the elongation of C-C bonds due to thermal expansion resulted in their Raman spectrums redshift