DOI: 10.51219./materialsscienceforum.2020.51.RLVander Wal

Laser Annealing of Carbons

R. L. Vander Wal*, J. P. Abrahamson, John and Willie Leone
Department of Energy and Mineral Engineering and the EMS Energy Institute, The Pennsylvania State University, University Park, PA, 16802, United States

Laser processing of materials is not new, but, using lasers to anneal, bond and otherwise transform carbons is. Fundamental understanding of the annealing dependence upon carbon structure, morphology and chemistry is critical to implementing this technology into manufacturing and processing applications. In this work a Q-switched Nd:YAG laser and a continuous wave CO2 laser are used to anneal carbon materials. Lasers provide rapid heating and cooling with high temporal control. The extent of transformation is kinetically controlled by time above the threshold temperature for transformation. Enabling the production of carbon structures not possible via traditional furnace annealing. Under the action CO2 laser radiation carbon can be heated to 2,600 °C in 1.4 ms. After 20 s, the structure is equivalent to that obtained from furnace annealing at 2,600 °C for 1 hr. as has been shown elsewhere. In contrast a Q-switched Nd:YAG laser with pulse width ~ 8 ns heats carbon materials to graphitization temperatures with a heating rate on the order of a few 1011 °C/s. The peak temperature is controlled by the laser pulse energy; typical temperatures range between 2,500 °C to the C2 sublimation temperature of 4,184 °C. The time at elevated temperature is limited (time above 2,000 °C is 1.5 μs). On this time scale, the long-range material motions are kinetically restricted. Consequently the Nd:YAG laser annealing trajectory deviates from traditional furnace pathways. The limited time at elevated temperature can be used for the purpose of surface modification. Surface modification via kinetically limited oxidation is one potential application. Another application is making connections between carbons without additional material.

Keywords: Carbon, Annealing, Laser, Graphitization, Nanostructure

Biography:

Randy Vander Wal is a Current research interests include CVD and flame synthesis of carbon nanomaterials, their application as conducting thin films, fundamentals of graphene bonding, carbon graphitization kinetics, carbon material characterization by high-resolution electron microscopy, HRTEM with image quantification for nanostructure, electron spectroscopic techniques, XPS, and EELs for bonding detail, and carbon materials' oxidation reactivity dependence on nanostructure. The optical, electrical and thermal properties of graphene and other graphitic carbon forms produced by pulsed laser heating is presently under study, as is the fabrication of advanced carbon-carbon composites based on these. Related study includes biochar production.

ISBN: 978-1-8382915-1-8