ANALYSIS OF PICOSECOND PULSED LASER MELTED GRAPHITE

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Abstract

A Raman microprobe and high resolution TEM have been used to analyze the resolidified region of liquid carbon generated by picosecond pulse laser radiation. From the relative intensities of the zone center Raman-allowed mode for graphite at 1582cm^{-1} and the disorder-induced mode at 1360cm^{-1}, the average graphite crystallite size in the resolidified region is determined as a function of position. By comparison with Rutherford backscattering spectra and Raman spectra from nanosecond pulsed laser melting experiments, the disorder depth for picosecond pulsed laser melted graphite is determined as a function of irradiating energy density. Comparisons of TEM micrographs for nanosecond and picosecond pulsed laser melting experiments show that the structure of the laser disordered regions in graphite are similar and exhibit similar behavior with increasing laser pulse fluence.

Introduction

Currently, the primary focus of pulsed laser irradiation studies [illegible] the interaction of a high power laser pulse with a crystal lattice. The pulsed laser heating technique can also be applied to the study of high temperature materials and their phase transformations. Studies of the effects of pulsed laser irradiation on carbon have been undertaken to determine the high temperature properties of graphite and liquid carbon [illegible]2,3]. From these studies different conclusions about the properties of liquid carbon have been drawn.

A possible cause for the controversy might be that graphite enters different phases depending upon the duration and power density of the heating laser pulse. Transitions to different phases could then result from differences in the pressure applied to the surface induced by vaporisation. A phase diagram proposed by Ferraz and March[4] incorporating two liquid phases is given in Fig.. The metallic liquid phase was observed by Bundy[5] during pulsed current heating of graphite rods at high pressure. Transient electrical conductivity measurements at low pressure by Jones[6] indicated the insulating liquid phase. The phase transition between the insulating and metallic liquid phases has not been observed experimentally, but the transition must be first order to account for the radically different properties of the metallic and insulating liquid phases[4]. The existence of two separate liquid phases of carbon might then explain the conflicting measurements of the optical and thermal properties of liquid carbon and determine whether liquid carbon has both a liquid metal phase[2,7] and a liquid semiconductor or insulator phase[3,8].

Experimental Results

Raman microscopy and TEM have been used to study the structural properties of the disordered region remaining after graphite is irradiated with 20psec Nd:YAG laser pulses at .532μm. The results have been compared with the results from similar measurements on the disordered region remaining after irradiation with 30nsec ruby