Laser-induced processes in carbon generated in an argon arc

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The interaction of pulsed Nd:YAG laser radiation with particles produced by a commercial carbon aerosol generator employing a discharge between graphite electrodes in argon has been studied under a variety of conditions. Other processes besides LII are observed and response to the laser pulses is very dependent on the composition of the carrier gas surrounding the particles.

Introduction

The Palas GfG1000 commercial 'graphite' aerosol generator is a convenient source of small carbonaceous particles. This device forms particles in an electrical discharge between graphite electrodes in a flow of argon. Air can be added to the gas flow after the discharge region to dilute the particle concentration. This device is a convenient aid for setting up LII systems for in-situ measurement in, for example, aero-engine exhausts, but the nature of the particles is different to combustion soot.

An unfocused Nd:YAG laser operating at 1064 nm was used to generate LII at the outlet of an alumina tube which carried the exhaust from the GfG 1000 through a tube furnace so that the temperature of the carrier gas could be varied. Fig.1 (taken with a Sony Mavica digital camera) shows visible LII at the outlet of the heated furnace. The 7-mm diameter laser beam traverses the lower right hand corner of the picture diagonally from right to left. LII appears as a bluish cylinder.

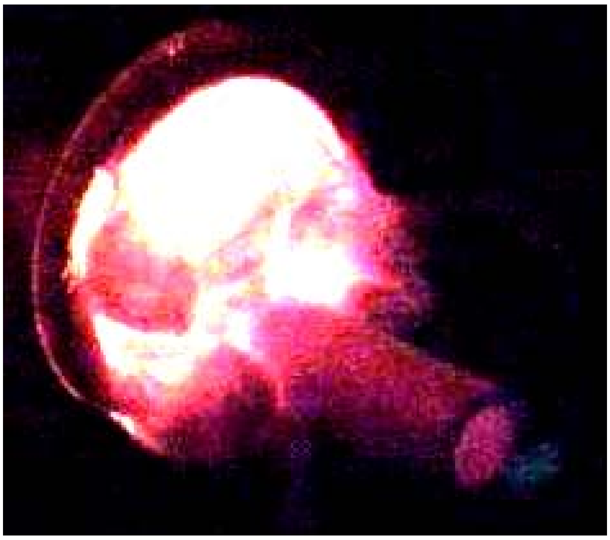

Fig. 1: LII from particles in an argon stream emerging from the tube in the lower right corner. The bright part of the image is insulation at the mouth of a tube furnace at ~1000°C, giving a 'colour temperature' reference to the LII, which appears much bluer.

Discussion

In a previous publication [1] we showed spectra of the LII in pure argon and 1:1 argon/air. With pure argon the spectrum peaks around 560 nm with some broad structure around the peak and a tail extending into the UV. When air is added LII signal levels drop drastically, as does the emission spectrum at wavelengths shorter than 550 nm. After initial dilution, LII scales linearly with the relative air flow.

This suggests that air acts to quench a laser-induced effect which dominates in a pure argon flow.

Fluence dependence has been studied in the range 0.03 – 0.3 J cm^{-2} for both argon and argon/air mixtures. In images of the LII taken in the first microsecond following the laser pulse very bright spots with dimensions < 0.1 mm are observed even at lower fluence levels in both argon and argon/air, although to a lesser extent when air is present.

The GfG 1000 probably produces a variety of different forms of carbon, e.g. graphenes, nanotubes, etc. Electron micrographs show very small particles ~10 nm. Investigations are continuing.

References

1 J.D. Black, M. Hilton, M.P. Johnson and D. Waterman, Proc. SPIE Vol. 5149, p. 265 (2003).

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