Prompt Heat Transfer Anomalies Observed with Two-Colour Laser-Induced Incandescence (2C-LII)

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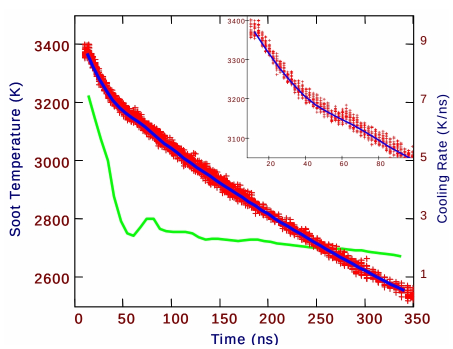
Concern has been raised over the observed rapid initial decay of temperature during and immediately after the laser pulse in laser-induced incandescence. This impedes the ability to make meaningful interpretation of signal and/or temperature decays for the sizing of soot nanoparticles. This anomalous behaviour is also shown to affect low-fluence measurements of soot volume fraction in low ambient temperature environments. It is proposed and evidence provided that the reason for this behaviour is that *E*(*m*) from the unperturbed soot at the lower measurement wavelength is high, possibly due to absorbed large PAH's or graphitization of the soot. At high fluence the initial cooling rate is shown to be much lower than that predicted by sublimation models.

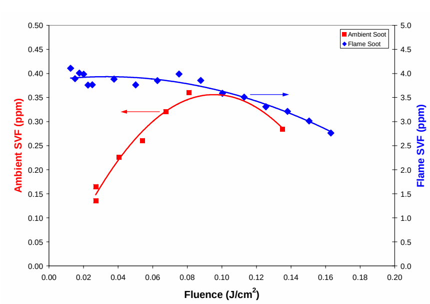
Introduction

The decay of temperature immediately after the peak of the laser pulse has been frequently observed to exhibit an accelerated rate for a short period of time (<100ns). Furthermore, numerous anomalies with LII have been observed, and these anomalies are substantially more evident when applying low-fluence LII to examine post-flame soot at lower ambient temperatures than when in-flame soot is studied. These anomalies include the soot volume fraction (SVF) varying with fluence, the absorption *E*(*m*) needed to predict the peak temperature appearing to vary with fluence, and the LII signal intensity required to produce a given temperature varying with fluence.



Evidence

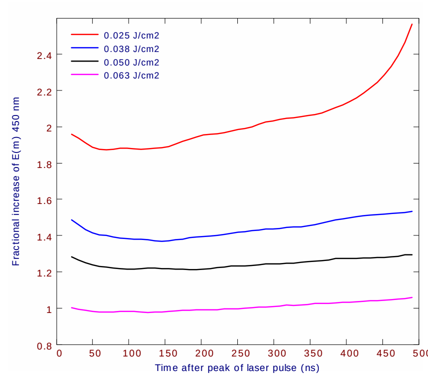
For soot at flame temperatures, the apparent SVF is essentially constant with fluence until the sublimation threshold is reached, after which it decreases with increasing laser fluence. However, for soot initially at ambient temperatures, as the fluence is increased there is a large increase in apparent SVF until it reaches a maximum at the sublimation threshold, after which SVF decreases.



Analysis

Assuming there is no real variation of SVF with fluence then at a single experimental condition the observed LII temperature can be used to "calibrate" the intensity, producing a scale factor to be applied to the Boltzmann equation to give the observed intensity. At the lowest fluence the intensity determined temperature is much lower that the LII temperature, with the higher wavelength based temperature being lower than that calculated from the intensity at the lower wavelength, but this discrepancy decreases as the fluence is increased.

The proposed explanation for this behaviour is that *E*(*m*) from the unperturbed soot at the lower wavelength is high, possibly due to absorbed large PAH's or graphitization of the soot, and that the laser heating causes a surface modification, "cleaning" the surface.



Assuming the SVF and *E*(*m*) at the higher wavelength are constant, the intensity based temperatures can be used to deduce the required increase in *E*(*m*) to result in the three temperatures coinciding.

Changes in the soot emissivity in the 350-500 nm range would explain the low fluence anomalies.

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Proceedings of the 2nd International Discussion Meeting and Workshop: Laser-Induced Incandescence, Quantitative interpretation, modelling, application, Bad Herrenalb, Germany, 2-4 August, 2006