An LII technique independent of *ex-situ calibration* by detecting absolute light intensity

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This paper presents a novel LII technique for the determination of soot volume fraction by measuring the absolute incandescence intensity, avoiding the need for *ex situ* calibration typically using a source of particles with known soot volume fraction. The technique developed in this study further extends the capabilities of existing LII for making practical quantitative measurements of soot. The spectral sensitivity of the detection system is determined by calibrating with an extended source of known radiance and this sensitivity is then used to interpret the measured LII signals. Although it requires knowledge of the soot temperature, either from a numerical model of soot particle heating or experimentally determined by detecting LII signals at two different wavelengths, this technique offers a calibration independent procedure for measuring soot volume fraction. Application of this technique to soot concentration measurements is demonstrated in a laminar diffusion flame.

Introduction

The LII technique was traditionally calibrated using a particle source of known concentration. For this conventional LII method, as long as there are no significant changes between the conditions of calibration and the LII measurements, the measured volume concentration should be relatively accurate. However, all particulates are not created equal. Calibrating in a flame at high temperature and then measuring at lower temperatures can introduce inaccuracies due to different peak temperatures. Furthermore, variation in the ambient pressure can also have an effect, as it impacts upon the sublimation temperature of elemental carbon. Because of these limitations of the conventional LII method, caution must be taken when applying the calibration constant obtained under a condition substantially different from the actual measurement condition in terms of the local gas temperature, the chemical compositions of the PM, and the ambient pressure. The object of this study is to develop a calibration-independent LII technique.

Methodology

The fundamental idea behind the present LII technique is that the soot volume fraction can be determined if the absolute spectral intensity of the incandescence signal emitted from the laser heated soot particles is measured and the temperature of the soot particles is known. To measure the absolute LII intensity the detection system must be calibrated using a radiation source of known radiance. The soot particle temperature is required to calculate the theoretical spectral emission intensity per unit volume of soot. The temperature of soot particles can be measured by detecting the LII signals at two different wavelengths. The detection system is calibrated using a strip filament lamp of known brightness temperature and thus known radiance. The optical set-up for absolute light intensity calibration is shown schematically in Fig. 1.

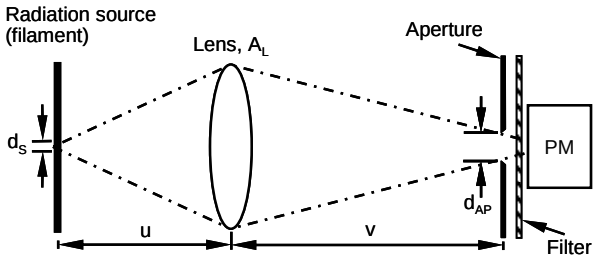

Fig. 1 Schematic of the optical setup for the calibration of absolute light intensity.

Results

Results of soot volume fraction measurement in a laminar diffusion flame using this LII technique are shown in Fig. 2. The LII results are in good agreement with that measured by 2D attenuation (4 ppm).

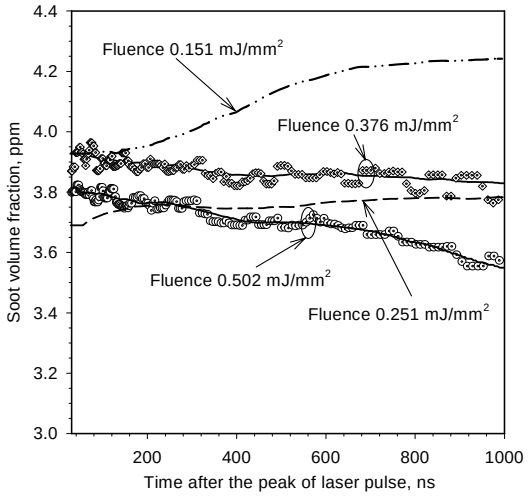

Fig. 2 Variation of the soot volume fraction measured using the present LII technique with laser fluences.

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