Laser-induced incandescence of free and surface-adsorbed particles

T. Schittkowski, D. Böker, D. Brüggemann*
Lehrstuhl für Technische Thermodynamik und Transportprozesse (LTTT)
Universität Bayreuth, Germany

The technique of laser-induced incandescence (LII) has been used to study non-soot, in particular silver particles. Experiments were based on experience with LII soot measurements and a sensitivity analysis regarding the influence of various parameters. Some experimental modifications, e.g. double laser pulse excitation, have been tested. A major extension of the LII technique consists in measurements of wall-adsorbed particles requiring appropriate models for data interpretation and evaluation.

Introduction

From its beginning the development of laser-induced incandescence (LII) as an in-situ diagnostics tool was mainly targeted on soot particles. Although some issues of soot measurements are still to be discussed and improved, LII can now be regarded as a standard technique which is widely used in combustion research of both laboratory flames and practical combustion systems (e.g. I.C. engines).

In comparison to soot relatively few studies have been dedicated to other types of particles. This may be surprising as the availability of a well-established technique for measurements on small particles with a good resolution in both, time and location, is of importance in the monitoring of formation or generation and the development and transport of other nano- or micro-sized particles (e.g. TiO_2, ZnO, Ag). Environmental conditions in the production processes of the nanoparticles may change drastically. The physical behavior of the particles on incoming radiation and the heat transfer to the surrounding differs through optical material properties and morphology as well as the surrounding medium. We have investigated the applicability of LII to solid particles and describe results for silver (Ag) particles as an example.

Furthermore we have extended LII experiments to the case where particles are adsorbed on a surface, in our case on a glass plate. Obviously this is more complex than the usual case of a group of freely moving individual particles as the wall attachment leads to additional heat transfer, natural or laser-induced agglomeration, structural deforming etc. Nevertheless there are practical situations where LII measurements on wall-attached particles may be of interest.

Experimental and Modelling Approach

Before beginning with our attempts to extend the LII technique we have checked our experimental set-up and data evaluation by conventional soot measurements. We used standard physical models and parameters which we assessed by a sensitivity analysis. Our experiments on soot particles included their dispersion in different atmospheres (air, argon) and their behavior towards double laser pulse excitation.

In a next step we have set up LII experiments for investigating silver particles. Free particles were excited and observed by using ultrasonic sonotrodes for their local stabilization.

Finally, the LII signals of silver particles adsorbed on a glass surface were investigated. A reasonable data evaluation has to be based on a model extended to describe the considerably more complex situation.

In addition some comparisons with data given by a scanning mobility particle sizer (SMPS) have been made. Furthermore, we investigated the influence of double laser pulses on LII signals as well as the effect of laser illumination on the adsorbed particles.

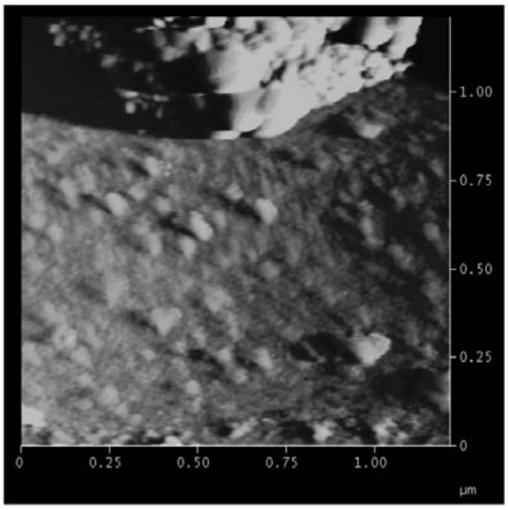

Fig. 1: Atomic force microscopic (AFM) view on the surface of a glass plate with silver particles of 30 nm and their agglomerations of typically 500 nm in diameter

Experimental results and underlying model assumptions are discussed with respect to their accuracy. Some of the drawn conclusions may be regarded to be quite reliable, while others encourage further studies.

* Corresponding author: brueggemann@uni-bayreuth.de
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