Defining a measurement strategy for 2D soot particle size imaging through detailed LII signal-decay analysis

E. Cenker[1,2], G. Bruneaux[1], T. Dreier[2], C. Schulz[2]

[1]*IFP En, Rueil-Malmaison, France,* ***emre.cenker@ifpen.fr***
[2]*IVG and CENIDE, University of Duisburg-Essen, Duisburg, Germany*

A combination of two-color soot pyrometry imaging, two-color time-resolved LII (TiRe-LII), Laser Extinction Method (LEM) and Transmission Electron Microscopy (TEM) of soot samples is used to define a strategy for two-dimensional imaging of soot particle size distributions. TiRe-LII is carried out both by single point measurements and 2D imaging, where LII signal-decay is determined for each pixel through time-gate-sweeping of the camera gate relative to the laser pulse. Experiments are carried out on an atmospheric laminar ethylene/air diffusion flame from a Santoro burner with a 1064-nm laser sheet operated in the low-fluence regime. For flame temperature measurements, two-color pyrometry images are tomographically inverted. The resulting temperature fields are used as input for the evaluation of the primary particle size from the local LII decay curves using the LIISim model.

It was found that the LII signal shows different decay properties at different delays after laser heating. As the particles cool down towards ambient temperature, calculated decay constants increase. For closer inspection, the TiRe-LII signal is divided into several 100-ns long segments and individual particle sizes are calculated for each segment by two-color LIISim curve-fitting. As the time-window is shifted further away from the laser, larger particle sizes are calculated. For a delay of 700 ns between two segments, the calculated particle size difference is greater than 12 nm. This variation is attributed to the polydisperse nature of the particle size distribution in the region of interest where small particles cool down to ambient temperature within a few hundred nanoseconds and their contribution to the detected LII signal fades out.

The dependence of the predicted particle sizes on the boundary conditions imposed for the simulation, such as ambient temperature, agglomeration, and accommodation coefficients are also quantitatively investigated. For validation of the evaluated particle sizes and uncertainty analysis, particles are sampled at different locations in the flame above the burner head via thermophoretic sampling on TEM grids. Primary particle sizes and dispersion are derived from TEM micrographs.

For the next step, these techniques will be applied in a high-pressure burner and a high-pressure spray vessel. In light of the time-segmented decay analysis, an optimized gate positioning for 2D-LII and a comprehensive simulation model strategy will be determined.