Understanding Soot Formation in Combustion Flames

Frederic Griesch and his colleagues from the CORIA research institute in France try to understand the formation soot particles in combustion flames. They use emICCD cameras for in situ observation of laser induced fluorescence of OH and aromatic molecules and laser induced incandescence to monitor soot particles.

In their article the researchers from France describe that there is significant environmental impact of soot particles produced in combustion processes although it has been underestimated for a long time. Areas that rely on combustion processes, for example the aviation industry, will likely face increased standards that require the development of cleaner combustion engines that reduce fuel consumption and soot production.

Soot particles of 10-50 nm diameter can form in a nucleation process starting from polycyclic aromatic hydrocarbon molecules (PAHs) that are produced by chemical decomposition of fuel during the combustion reaction. To better understand the soot formation, process the researchers use optical imaging techniques to simultaneously observe OH molecules, PAH molecules using planar laser induced fluorescence (PLIF) and soot using laser induced incandescence (LII). OH is an abundant molecule in the reaction region of flames and is observed to determine the location of the reaction front in the flame.

PLIF measures the fluorescent emission from molecules that are excited to a higher electronic state by a laser. For PLIF measurements the researchers create a thin light sheet from an ultrashort laser pulse using cylindrical lenses. The PLIF signal is observed perpendicular to the laser sheet on a PI-MAX4 emICCD camera with a 15nm bandpass filter centered 315 to select the emission of OH molecules. The emICCD is synchronized with the laser and operated around 50ns gate width. The short gate times make sure that the very short PLIF signal is detected while the background light from the flame is suppressed. Similarly, the PLIF signal from PAHs is selected on a second PI-MAX4 emICCD camera using filters to only detect emission above 325nm.

LII measures the thermal emission from the soot particles that are heated by the ultrashort laser pulse. The LII signal is detected on the same camera as the PAH-PLIF signal using 100ns gate width.

The laser induced measurements are combined with particle image velocimetry measurements to illuminate the aerodynamic processes of the combustion reaction.

The multichannel, simultaneous optical imaging technique is successfully applied to characterize the soot formation mechanisms in a combustion flame and will be useful for future investigations of soot formation.

Publication: On the use of PIV, LII, PAH-PLIF and OH-PLIF for the study of soot formation and flame structure in a swirl stratified premixed ethylene/air flame

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Related Products: PI-MAX4 (emICCD)