FOCUS ON IMAGING

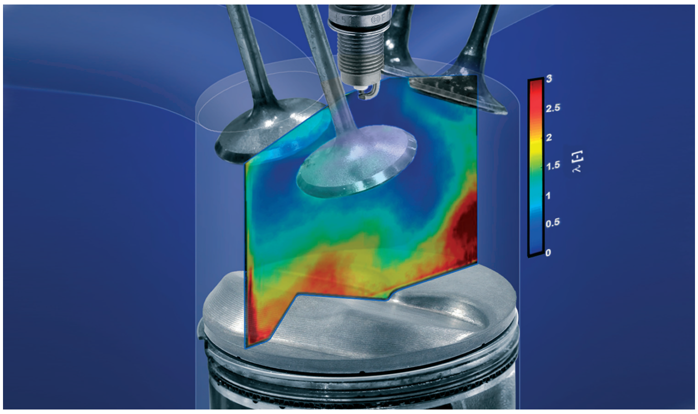
In Application

Multi-Parameter LIF Imaging in IC-Engines
New LIF Tracers for Fuel/Air Ratio Imaging and Flame Visualization

EngineMaster multifunctional laser imaging system

Introduction

LaVision's **EngineMaster multifunctional** system based on multi-wavelength Nd:YAG lasers supports laser imaging of fuel, fuel/air ratio, gas temperature and soot measurements together with flame imaging. Reaction zone visualization based on OH-LIF is possible in combination with LaVision's T-YAG module or - as a new approach - applying SO_2-tracer LIF instead of OH-LIF. For fuel/air ratio-LIF (FAR-LIF) a more efficient LIF tracer is validated featuring better LIF performance at extremely lower seeding concentrations. Laser imaging in engines benefits from both simplified LIF strategies in combination with structured laser sheet illumination (**SLIPI**) for stray light rejection.

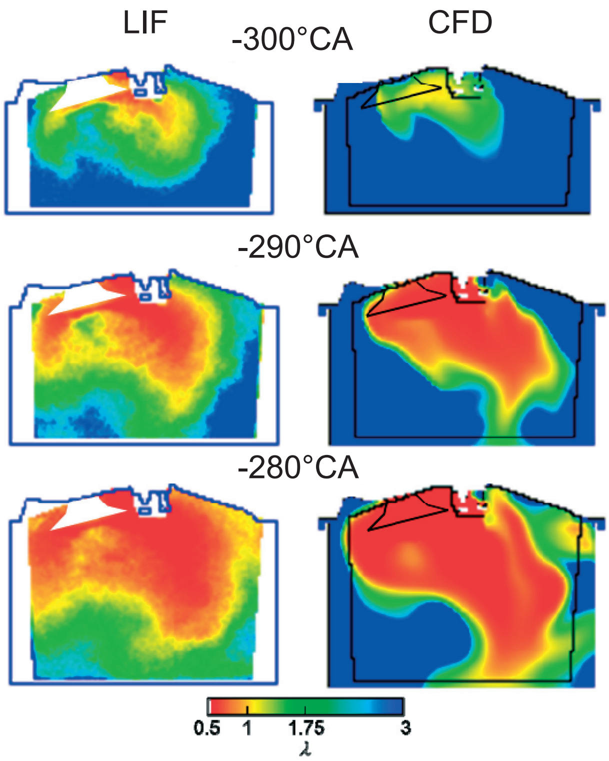


Air/fuel ratio LIF imaging inside the combustion chamber during mixture formation of methane and air.

New LIF tracer for fuel/air ratio measurements

Mixture formation in internal combustion (IC) engines is one of the critical parameters affecting the combustion process as well as the pollutant emissions. Within a government funded project ("Optical measurements of mixture formation in natural gas engines") LaVision together with its cooperation partners (University of Duisburg-Essen, Laser Laboratorium Göttingen and Volkswagen) have successfully tested a new LIF tracer for fuel/air ratio imaging in gas engines [1]. Compared with traditional LIF tracers used for this purpose the new tracer generates higher LIF signals at much lower seeding concentration levels additionally reducing unwanted laser beam absorption effects.

This new LIF tracer was successfully applied in a methane-fueled and fired gas engine measuring instantaneous and averaged air/fuel (λ)-distributions. The LIF image quality was further improved realizing nearly background-free laser imaging, i. e. only directly scattered LIF photons were detected. This was achieved applying the innovative **S**tructured **L**aser **I**llumination **P**lanar **I**maging (**SLIPI**) technique in combination with Fourier filtering. The experimental data were compared with CFD simulations showing good consistency over a large range of crank angles. In parallel LaVision's **ICOS** absorption sensor was used for crank angle resolved air/fuel ratio (λ-) measurements locally near the spark plug.



Measured (left) and calculated (right) λ-maps during intake phase inside a methane-fueled engine.

References: [1] P. Kranz et al., "In-cylinder LIF imaging, IR-absorption point measurements, and a CFD simulation to evaluate mixture formation in a CNG-fueled engine", SAE 2018-01-0633

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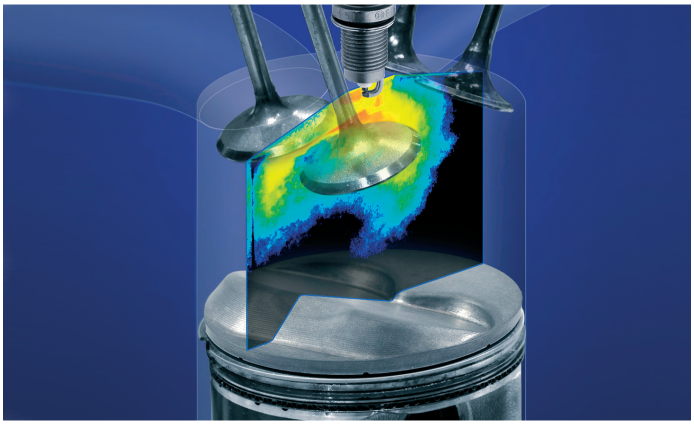
SO_2-LIF for reaction zone visualization

For flame (front) visualization OH- (CH-) LIF imaging is used in combination with a UV dye laser. OH-LIF imaging can also be performed with modified Nd:YAG lasers upgraded with LaVision's T-YAG module. Our cooperation partner TU Darmstadt has successfully investigated SO_2-LIF for flame visualization using a standard UV Nd:YAG laser [1]. SO_2 survives high flame temperatures, and the SO_2-LIF signal excited at 266 nm is strongly temperature-sensitive. Therefore, SO_2-LIF imaging is a suitable method for flame visualization studies.

The research group at TU-Darmstadt carefully validated the temperature dependence of the SO_2-LIF signal in a laminar flame and in an optical engine, and compared SO_2-LIF imaging with OH-LIF imaging under the same experimental conditions. The combustion process was not influenced by adding low SO_2 seeding concentrations in both experiments. For the applied seeding concentrations the SO_2-LIF signals showed higher signal to noise ratios compared with the OH-LIF signals and followed the temperature rise over the flame front more faithfully.

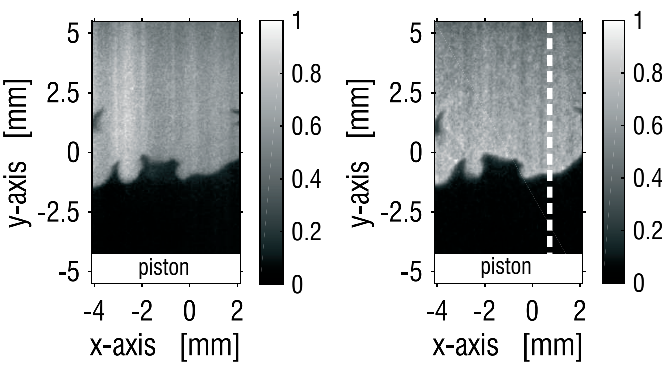
Thus, SO_2-LIF is an attractive laser imaging technique for flame imaging in combustion processes without the experimental complexity of a dye laser based OH-LIF system.



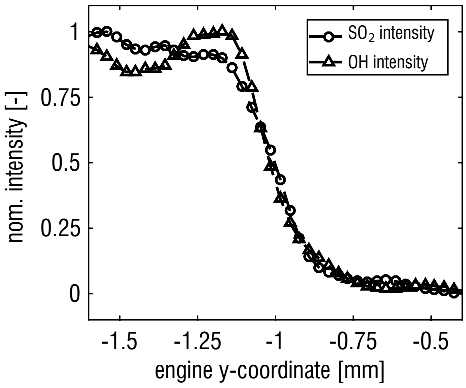
In conclusion, LaVision's **EngineMaster** laser imaging system is a valuable measurement tool to improve computer simulations and to investigate the highly complex processes in modern engines.

LaVision's **EngineMaster multifunctional** system supports the following in-cylinder measurements:

- fuel spray injection
- mixture formation: air/fuel ratio (λ-maps)
- gas temperature before ignition
- reaction zone visualization
- soot concentration imaging



Flame visualization inside an SI-engine using simultaneous SO_2-LIF (left) and OH-LIF (right)



SO_2- and OH-LIF profiles taken along the dashed line from both LIF images

Reference: [1] R. Honza, C. Ding, A. Dreizler, B. Böhm, "Flame imaging using planar laser induced fluorescence of sulfur dioxide", Appl. Phys. B 2017

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