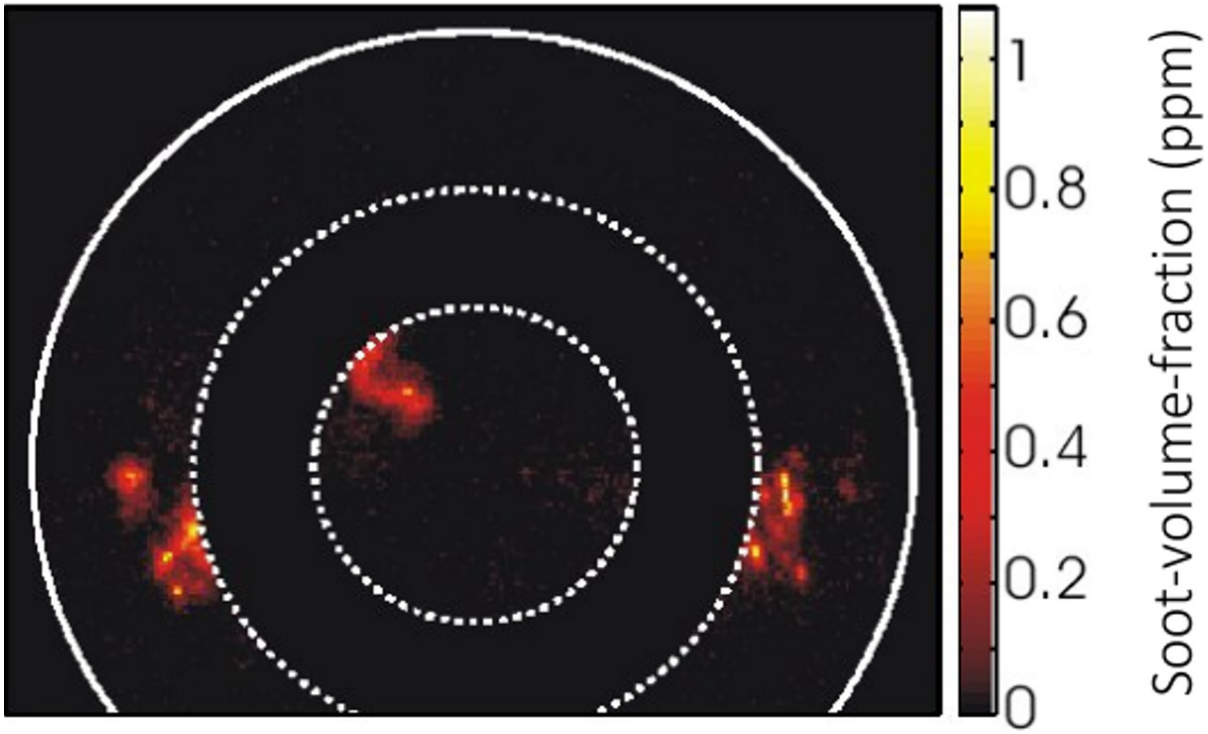
SOLUTION SHEET

DANTEC DYNAMICS

LII System

Soot-volume-fraction measurements by Laser-Induced Incandescence



Quantitative soot-volume-fraction imaging

Combining the latest developments in laser and imaging technology with our user-friendly software, the Laser-Induced Incandescence (LII) system is a powerful tool for soot diagnostics. With full control over data acquisition and analysis, the system offers quantitative 2D imaging of soot-volume-fraction and carbon concentration, and is well suited for applications in open laboratory flames as well as IC engines and industrial environments.

Key benefits

- Non-intrusive imaging technique for measurements of soot volume fraction and carbon concentration
- Compact yet powerful laser solution with excellent beam quality
- High sensitivity camera
- Advanced synchronization with temporal precision down to sub-nanoseconds
- Complete software platform for system set-up, data acquisition, data analysis and visualization of results
- Software module for calibration and processing data to gain direct information on soot-volume-fraction (in ppm) and carbon concentration equivalent (in mg/cm^3)

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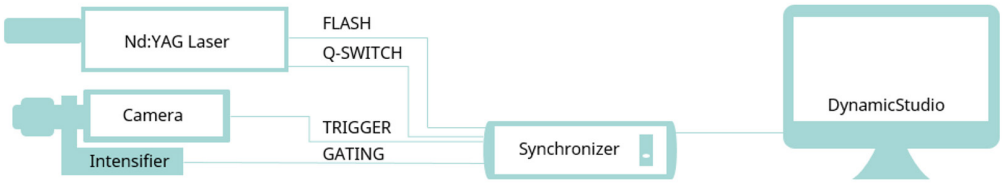
Soot diagnostics for combustion applications

Soot is considered a hazardous pollutant emission and is typically the result of incomplete combustion processes, and thus related directly to combustion performance. Laser-Induced Incandescence (LII) is a laser-optical measurement technique dedicated to soot diagnostics. LII can provide measurements of soot volume fraction (e.g. in diesel engine exhaust) and even instantaneous images of soot distribution during formation inside a running IC engine.

The LII system in brief

Laser-Induced Incandescence data is obtained in a plane by illuminating the process under investigation with a thin laser light sheet. The illuminated soot particles absorb the light and are heated up by the laser excitation to very high temperatures. As a consequence of the increased temperature, the soot particles emit increased levels of black body (Planck) radiation or incandescence. The incandescence is then recorded by an intensified camera placed perpendicularly to the light sheet. As the incandescence intensity is related to the soot-volume-fraction, quantitative soot volume fraction measurements can be made, with a proper calibration.



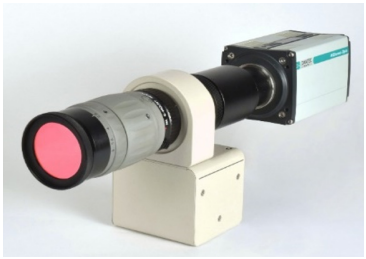
Overview of the different components, timing and data flow.

Laser light source

The Nd:YAG laser, optimized for 10 Hz repetition rate, is equipped with a temperature stabilized 2nd harmonic generator which provides 430 mJ at 532 nm. The 2nd harmonic unit comes with intelligent auto-tuning to maintain optimum phase matching and maintain maximum output energy over time. The laser is easy to operate and does not require external water-cooling or other complex infrastructure. Our robust Light Sheet Optics are included with the system and provide a parallel laser sheet for consistent light intensity. A parallel light sheet is required to assure that the intensity distribution, over the laser sheet height, is the same over the observed length of the Field-of-View. Light sheet dimensions are approx. 50 mm x 0.1 mm (when used with a beam waist adjuster) with a working distance of 600 mm. To ensure a secure working environment, laser alignment goggles and protective goggles are available.

Cameras, Image Intensifiers and Lenses

The standard camera for Laser-Induced Incandescence is the HiSense Zyla camera featuring high sensitivity and low noise levels.
The image intensifiers are designed for UV, visible and near-IR applications using a broadband Multialkali or S20 photocathode in order to cover a wide range of combustion related applications. The units offer full control over gain and gate time options ranging from continuous to ultra-fast, with a minimum gate time as low as 3 ns depending on the model. Relay optics used to adapt the camera to the image intensifier are also included.
We offer a wide range of camera lenses for visible light, together with an adapter ring for fitting filters to the selected lens. Each system includes a lens to optimize the magnification and field-of-view for the scope of the measurement along with the option of an interference filter for Rayleigh Thermometry.



HiSense Zyla camera, image intensifier unit and front lens

The camera and image intensifier are separate units, allowing for flexible use of the hardware. This solution is ideal for laboratories dealing with multiple applications such as LII, Rayleigh Thermometry, LIF, PIV, microscopy and spectroscopy.

High Performance Synchronizer

Synchronization of laser pulses, cameras and image intensifiers is mastered by a High Performance Synchronizer, fully controlled via the DynamicStudio software. The synchronizer is a multi-channel delay and signal generator with <= 1 ns resolution. The 32 output channels are programmed independently; thereby offering comprehensive synchronization and triggering facilities for highly demanding processes. It also features four input channels for synchronization with external devices or events, two analog inputs with up to 500 kHz sample rate, and four analog outputs. For further details, please consult separate data sheet on “Imaging Synchronizers”.

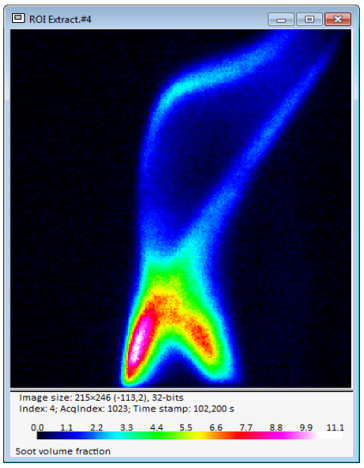
High performance synchronizer

User-friendly imaging software platform - Straightforward data analysis

The image acquisition system is based on DynamicStudio, a comprehensive and user-friendly software platform for imaging applications. It features an advanced plug-and-play based distributed system, making it easy to get full control over the hardware for image acquisition. Data acquisition and analysis are supported within the same software, so there is no need to export the data for post-processing.

The LII software add-on contains dedicated calibration and processing routines. The LII routine offers quick and reliable calibration by simply recording a single set of LII images at well-known conditions. The calibration sequence only requires specifying two distinct regions in the image set with known soot levels; checking the scale option, ‘in ppm’ (linear-linear calibration) or ‘mg carbon/cm^3 (log-log calibration); and completing the simple laser light sheet information dialog. The result is an accurate calibration which can be used for direct transformation of LII images into ppm or carbon concentration equivalent maps.

In the LII Processing, the calculation of soot-volume-fraction or carbon concentration equivalent is performed based on the previously generated calibration. With automatic compensation for laser energy and distribution variations between pulses, the image processing is both simple and accurate. To make image processing even more reliable for sooty combustion processes, we have developed advanced algorithms which compensate for non-linear absorption phenomena on individual soot maps. This High-Accuracy Module enables data correction based on energy budget, local energy absorption calculations and penetration lengths.



Soot-volume-fraction measurement in a sooting diffusion flame.

Boosting analysis capabilities with analysis sequences and MATLAB® Link

The data analysis is further strengthened by the ability to define analysis sequences and perform batch processing which makes quick work of processing large data sets. And with the MATLAB Link in DynamicStudio, you can tailor your analysis by calling up your personally designed MATLAB scripts directly from DynamicStudio, allowing you to process the data directly in the database without the need to export.

Option

Pulse Energy Monitor

A proven method of reaching higher accuracy is to measure the laser pulse-to-pulse fluctuations by means of a Pulse Energy Monitor and subsequently compensate for this during LIF image analysis. The Pulse Energy Monitor is mounted between the laser output and the light-sheet optics.

Technical specifications

Laser	
Wavelength (nm)	532
Pulse energy (mJ)	430
Pulse duration (ns)	~5
Repetition rate (Hz)	10

Light sheet optics	
Wavelength range	UV and visible
Light sheet height	50 mm

Camera	HiSense Zyla
Speed (fps) with frame grabber/with USB	49/40
Resolution (MP)	5.5
Sensor resolution (pixels)	2560 x 2160
Pixel size (µm)	6.5
Lens mount	F-mount or C-mount

Image intensifiers*	H Series 18 mm	L Series 18 mm
Minimum gate time	3 ns	
Photocathode diameter	18 mm	
Photo cathode material	Multialkali	S20
Phosphor screen	P43	
Camera attachment	C-mount	
Lens attachment	F-mount	

Camera lenses and filters	
Focal length and aperture	50mm f/1.4, 85mm f/1.4, 100 mm f/2.0
Filter adapter	Adapter for 62 mm filter included
Lens mount	F mount

High Performance Synchronizer	
Time resolution	<= 1 ns
Synchronization outputs	32, TTL
Synchronization inputs	4, TTL

Software	
DynamicStudio	Base package LII Add-on

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