Artium

High-precision measurement systems for energy, environmental, and industrial applications

Laser-Induced Incandescence

Measures:
Soot Concentration
(mass or volume basis)
Specific Surface Area
and
Primary Particle Diameter
in Real-Time

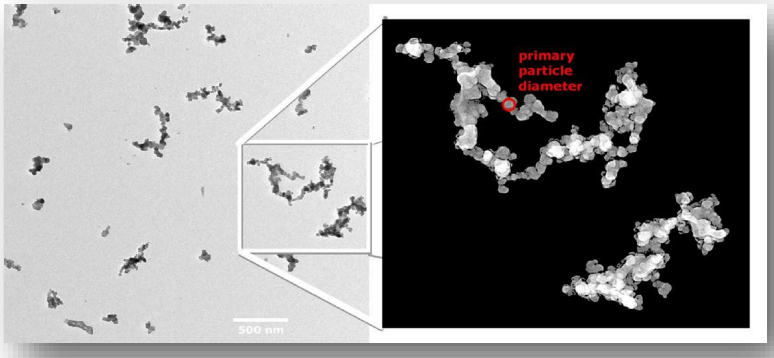
LII-300 Instrument for Soot Characterization

The LII-300 is the most advanced laser-induced incandescence instrument available in the market today. Laser-induced incandescence is an optical technique for accurate, non-intrusive, and temporally resolved measurement of soot concentration, specific surface area, and primary particle diameter.

Why are soot emissions a serious concern?

Increasingly, health researchers are discovering that soot itself is implicated directly in the numerous health effects attributed to particulate matter and poor air quality. Medical research over the past decade has revealed that microscopic soot particles are among the most harmful components of air pollution.

Environmental researchers have also identified black carbon as a key contributor to radiative forcing, which is important to climate change.



TEM image of soot nanoparticles showing the irregular structures of the aggregates.

Due to its low reactivity and low volatility, soot can be reliably measured regardless of temperature and dilution conditions that affect many of the other constituents of particulate matter.

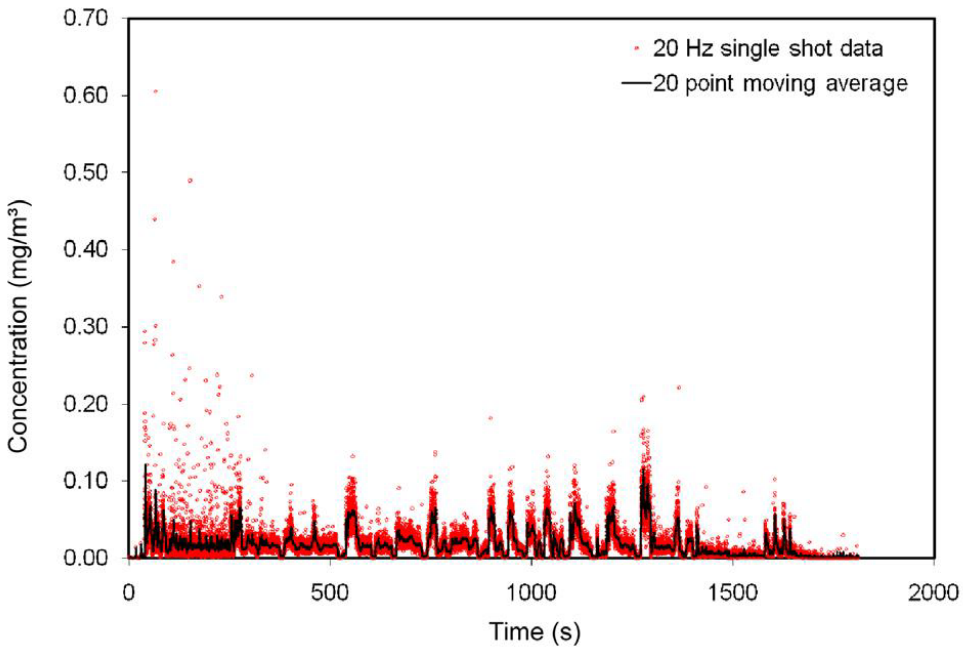
WHAT IS SOOT?

Soot refers to the dry solid particles produced through the incomplete combustion of hydrocarbon fuels.

Other terminology used by specialists from a range of fields to describe similar or identical nanoparticles includes:

- Elemental carbon (EC)
- Black carbon (BC)
- Carbon black (CB)
- Refractory carbon (RC)

Although the definitions for each may be specific to a field, LII is effective in measuring all of these.



On-road measurements of diesel soot acquired in real-time from an unattended Artium LII instrument. Single-shot results (red dots) and 20-shot running average (black line) are shown.

APPLICATIONS

The LII 300 can be applied to measure soot in many applications, including:

- On-road mobile emissions
- Diesel engine exhaust
- Gasoline engine exhaust
- Diesel particulate filter performance
- Advanced and alternative fuels, including biofuels
- Gas turbine particulate emissions
- Ambient air monitoring
- Atmospheric black carbon levels
- Urban air quality
- Carbon black production

For engine emissions, LII 300 may be reliably applied directly to raw exhaust or to dilute exhaust.

Laser Induced Incandescence Technology (LII) involves measuring the thermal emission (incandescent light) emitted from particles heated by a pulsed laser to temperatures in the 2500 K to 4500 K range. LII is highly selective, responding only to the presence of black carbon, making it decidedly appropriate for measuring the nonvolatile particles produced as a combustion emission. This selectivity is due to the fact that the nonvolatile particles are primarily black carbon. Black carbon is the primary and most stable constituent of particulate matter emissions from combustion. BC absorbs laser radiation over a broad spectral range, and is refractory, so that the nanoparticles survive heating to the temperatures necessary for the incandescence to be detected. At these temperatures, all volatile components that may have been condensed on the BC particles will be promptly evaporated, and most other nonrefractory particles will have also evaporated or undergone sublimation. Due to this selectivity, LII does not measure the total particle mass, but only mass of non-volatile particulate matter (nvPM.)

Turbine engine (helicopter) tests at Wright Patterson

A community of science has developed to advance the LII technique at a large number of organizations around the world, and a number of international workshops, to assess the improvements in the LII technique have been held since 2005 (www.liiscience.org).

Selected by SAE E31 committee as the standard for gas turbine nonvolatile particulate matter mass emissions measurements.

LII signal analysis results in the determination of the mass concentration, volume concentration, active surface area, and primary particle diameter of the particulates. In this context, primary particle diameter refers to the geometrical diameter of the spherical black carbon based particles formed during the combustion of hydrocarbon fuels; often these particles fuse together in the combustor to form a single nonspherical larger particle known as an aggregate. LII does not measure the size of the aggregates emitted from the combustor. The measurements made with LII are produced with each laser pulse at a 20-Hz rate, permitting online time-resolved data collection and reporting of results in real time.

Auto-compensating laser-induced incandescence (AC-LII) enhances the LII technique by recording the temperatures of the irradiated particles during the measurement process. This technique automatically compensates for any changes in the experimental conditions, including fluctuations in local ambient temperature, variation in laser fluence, laser beam attenuation by the particulate matter, or desorption of condensed volatile material. The LII 300 instrument produced by Artium Technologies distinguishes itself from other LII instruments by being the only commercially available instrument offering AC-LII.

AC-LII is based on the use of a traceable calibration source to establish the spectral sensitivity of the instrument to incandescence.
Measurement at two distinct spectral bands enables real-time two-color pyrometry to measure particle temperature. This automatically compensates for:

- Fluctuations in local ambient temperature
- Variation in laser fluence
- Laser beam attenuation by the particulate matter
- Desorption of condensed volatile material

These are issues that often affect conventional laser -induced incandescence (LII).

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The **Artium LII 300** instrument is configured for quick set up and unattended operation.

Connections:

- Sample line from source of particulates
- Exhaust line
- Standard electrical outlet
- Compressed air source
- Data line to acquisition system

Operation:

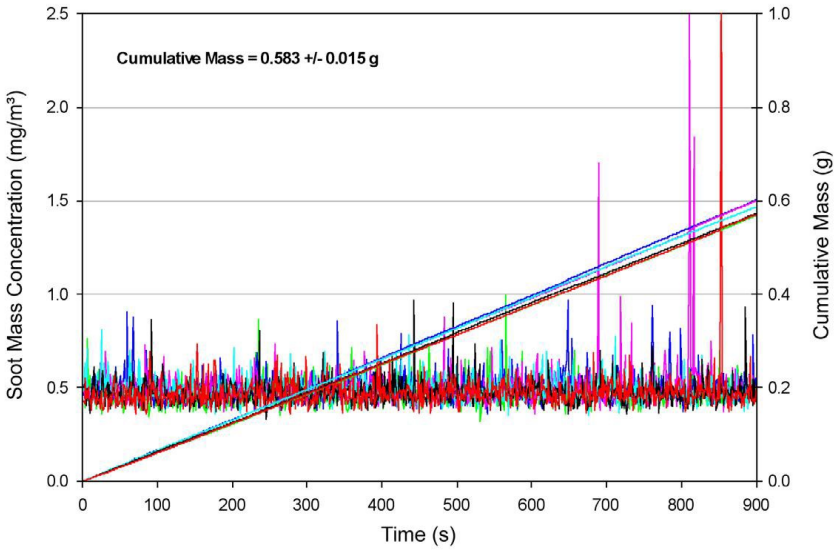
- Simple start/stop from touch screen interface
- Remote control option

Features:

- Fast, convenient, reliable and easy to use
- Very high sensitivity
- Auto-compensating
- Rugged, portable system capable of extended operation without maintenance
- Measures raw exhaust or from a dilution tunnel (no dilution required)
- Measures soot independent of condensed volatile or organic material (high selectivity)
- Does not assume the soot aggregate to be spherical
- Two-color pyrometry for measuring the soot temperature
- Completely enclosed laser, optics, and sampling cell
- Built-in pneumatics controller and sampling system
- Includes real-time pressure and temperature measurements to reduce data to STP
- Top-hat laser beam profile for uniform heating
- Fail safe valve prevents sample from entering cell if purge air or power are off
- Self-check of operation and calibration
- Does not require precise conditioning of the sample
- Vehicle onboard monitoring
- Proprietary NIST Traceable Calibration method

Specifications:

All Measurements:	
Sampling Frequency	20 Hz
Concentration:	
Low end	<0.1 part per trillion
	<0.2 micrograms/cubic meter
High End	10 parts per million
	20 grams/cubic meter
Dynamic Range	>1,000,000:1
Precision	+/- 2%
Primary Particle Size:	
Range	10–100nm
Precision	+/- 2% of max
Specific Surface Area	50-200 m^2/g



LII demonstrates better than 3% repeatability on heavy-duty diesel steady-state testing and gas turbine particulate matter (PM) emissions.

Our offices, research facilities, and manufacturing plant are

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