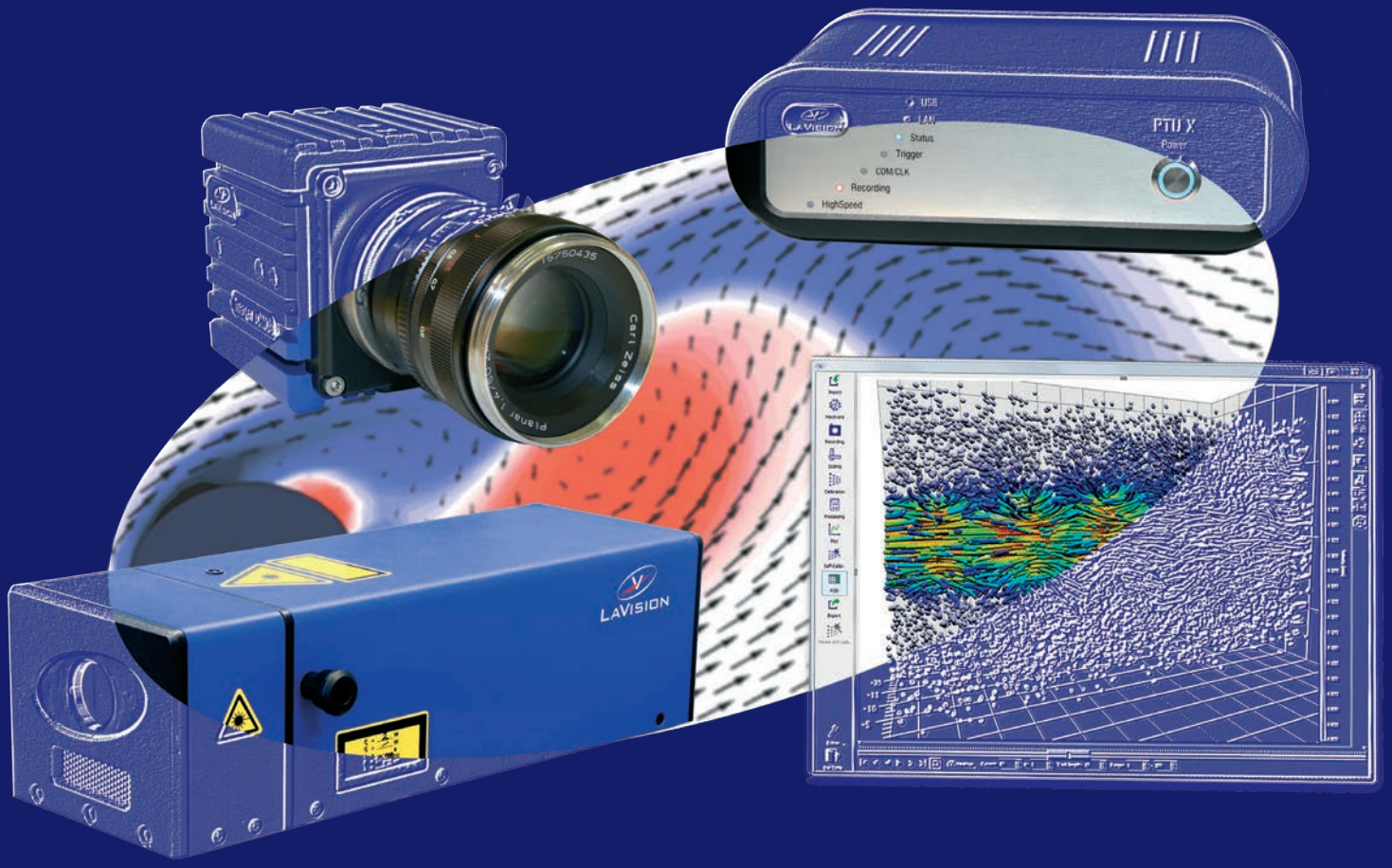


Intelligent Imaging

Product Guide

LAVISION

FOCUS ON IMAGING

LaVision

The Imaging Company

LaVision was founded in 1989 in Göttingen, Germany. Since its foundation LaVision is the leading supplier of laser imaging systems in research relevant application fields like fluid mechanics (aerodynamics, microfluidics), combustion (automotive, power generation) as well as spray and particle diagnostics (engines, pharma). Camera-based surface inspection systems and in-cylinder infrared-sensors are also part of the product portfolio.

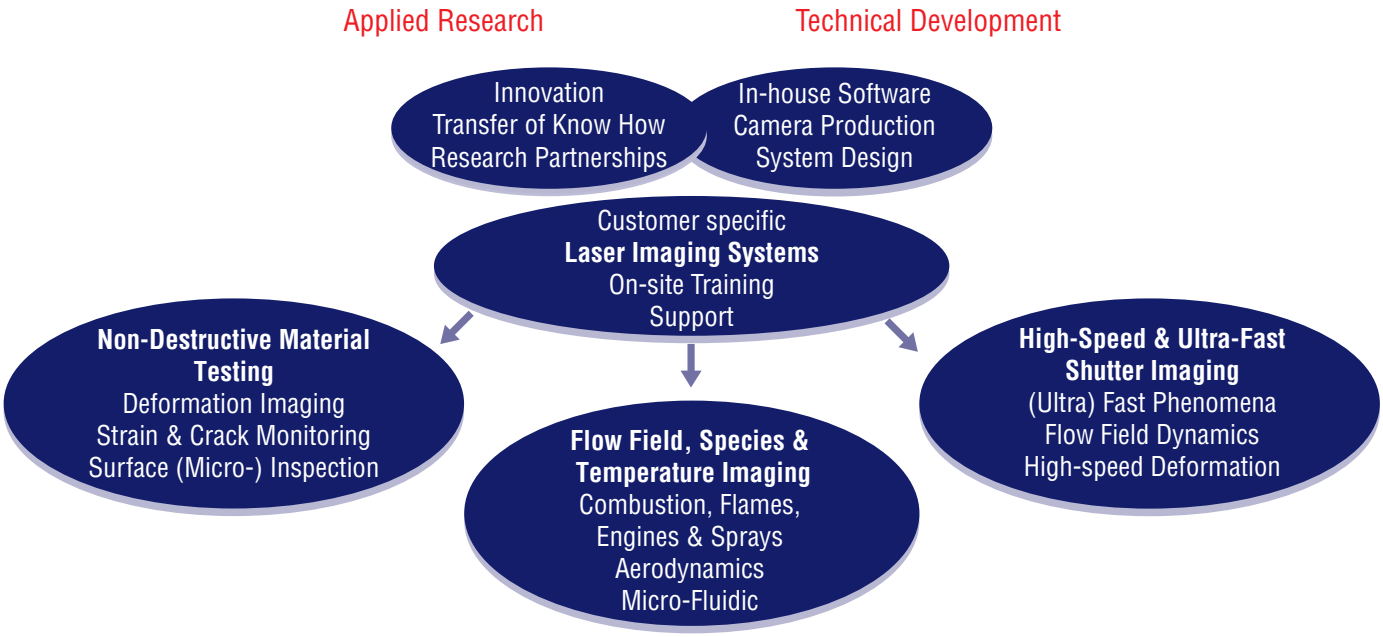
Due to their non-intrusive nature our optical instruments offer unique capabilities for multi-parameter flow measurements with high spatial and temporal resolution. Our measurement equipment is used in well-known R&D labs all over the world. Largely customer oriented, we offer user-friendly, reliable and high-quality products tailored to the needs of our customers.

The LaVision team has extensive professional experience in laser and camera technology, imaging techniques for flow analysis, spectroscopy and digital image processing. LaVision is cooperating with leading research institutions and companies around the globe and is serving the worldwide markets through their subsidiaries or representatives.

As a supplier of innovative (laser) imaging systems and optical sensors LaVision has established a strong reputation as a solution provider among its customers from various industrial and academic research fields. Very often our systems are used in automotive, aerospace or power generation, e.g. for the development of more efficient and cleaner combustion processes. Multi-dimensional velocity fields in wind tunnels, flame temperature and composition, particle concentrations and diameters are measured in-situ separately or simultaneously with high temporal and spatial resolution. In process engineering our in-situ measurement methods are applied to analyze mixing processes in multiphase flows. Materials testing benefits from our highly accurate non-contact measurement systems for deformation and strain measurements.

In process and quality control, e.g. for in-line leakage tests in the pharmaceutical industry or the analysis of spray nozzles for fuel injectors, our systems contribute to a significantly higher product quality.

For LaVision the customer is always in focus of our business.



Customer Partnership

The LaVision team welcomes and encourages detailed discussions with prospective customers regarding their application and measurement requirement. LaVision's system approach involves design and selection of system components, system integration, application-specific software development, calibration and detailed protocol of system performance. LaVision excels in providing on-site customer training and support including contract work.

Product Range

The LaVision family of laser imaging systems builds up a complete multi-technique framework for quantitative visualization of reactive and non-reactive flows. Multi-parameter measurements (velocity, species concentration, composition, temperature, particle sizing) are possible using multi-technique approaches.

Applications	Laser Imaging Techniques						Imaging Systems
	Mie	LIF	PIV	Raman	Rayleigh	LII	
Flows & Fluid Mechanics	Flow Structure Patternation	Flow Visualization Mixing	Flow Field	Composition Temperature	Gas Density Gas Temperature		FlowMaster FluidMaster
Sprays	Droplets Patternation	Liquid (Fuel) Mass Liquid / Vapor	Flow Field	Liquid / Vapor Temperature			SprayMaster ParticleMaster
	Planar Droplet Sizing	Mass Flux					
Combustion & Engines	Particles Droplets	Radicals, Fuel Chemical Processes	Flow Field	Gas Composition Temperature	Gas Density Gas Temperature	Soot	FlameMaster EngineMaster
Materials Testing Surface Deformation	Advanced Image Correlation						StrainMaster
	2D & 3D Deformation, Strain Field, Stress						
for all above Applications	High-Speed Imaging						High-Speed Master Systems
	Time-resolved History of Transient Phenomena & Time - Space Correlations						

StrainMaster

Optical Tool for Shape, Deformation and Strain Analysis

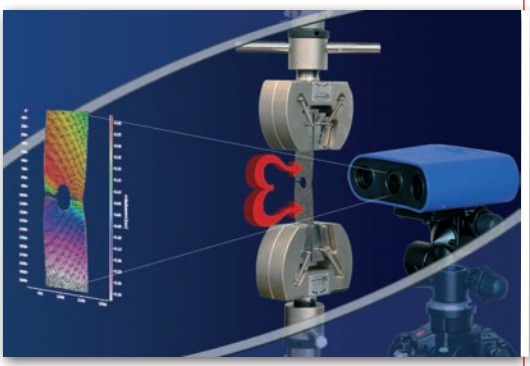
StrainMaster from LaVision is a state-of-the-art, non-intrusive optical tool for shape, strain and deformation analysis of solid and granular subjects. **StrainMaster** combines the most advanced **digital image correlation** (**DIC**) algorithms with the highest quality of hardware to provide a complete and easy to use instrument for material analysis. A range of **StrainMaster** systems are available from portable field work systems to highly specialized lab versions.

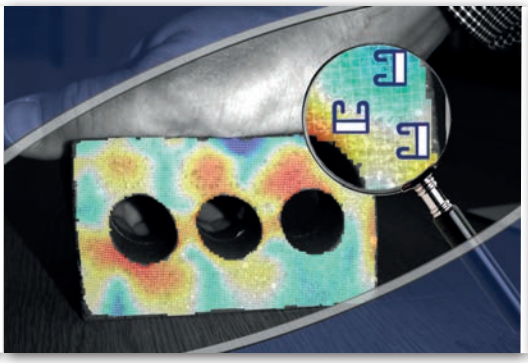
2D / 3D Digital Image Correlation

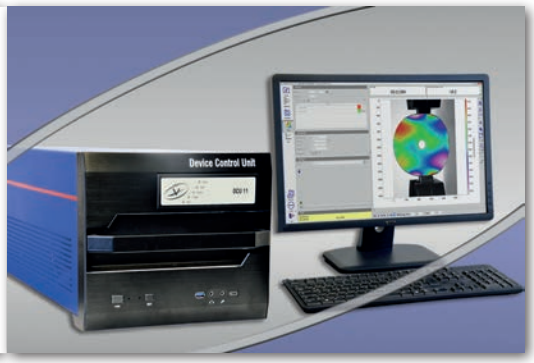
Unlike many standard digital image correlation systems, LaVision's **StrainMaster** is insensitive to the speckle pattern distribution and in many cases the natural surface of the material is quite sufficient to allow the acquisition of highly precise displacement and strain data. **StrainMaster** systems provide turnkey imaging solutions for various materials testing applications. The systems include all necessary components: high resolution digital cameras, illumination units, synchronization electronics, mounting mechanics and software for recording and data analysis.

Applications

- strain measurements of solids
- long term flow stress experiments
- ultra-fast deformation analysis
- granular flows
- low cycle fatigue tests
- Thermal Mechanical Fatigue (TMF) tests







System Features

- complete camera integration including high-speed devices
- Device Control Unit (DCU) X for synchronization of devices with integrated A/D converter
- complete control, analysis, and data management within one software package
- total control over data post-processing – your raw data is always available
- compact and robust mechanics
- live gauge extensometer mode with optional scaled analogue output for strain control
- comprehensive 3D display of data
- virtual gauge and extensometer plot
- dedicated add-on for MATLAB®, and export formats including ABAQUS® INP

Digital Volume Correlation

LaVision's state-of-the-art **digital volume correlation** (**DVC**) software is a novel technique for full volume 3D strain and deformation mapping. DVC is capable of identifying defects and cracks before they are visible in the raw image, and to quantify material characteristics. The technique imports volume images of the component in reference and deformed states. Images are typically acquired from X-ray Computed Tomography (X-ray CT) systems, but can equally be obtained by Magnetic Resonance Imaging (MRI) systems for biological subjects, or via optical tomography for transparent media.

ParticleMaster

Size and Shape Analysis based on Shadowgraphy Technique

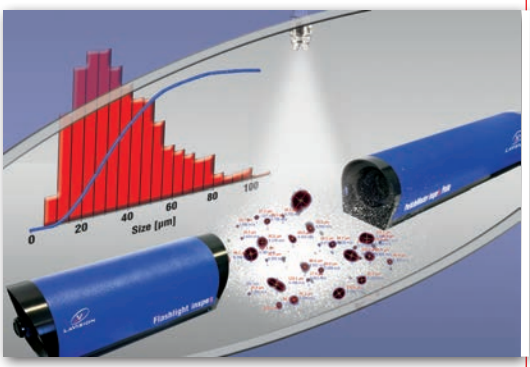
LaVision's **ParticleMaster** imaging systems measure simultaneously size, shape and velocity of individual particles, droplets or bubbles dispersed in gas, liquid or multiphase flows. High magnification shadow imaging with eye-safe LEDs or ultra-short laser pulses is applied giving confidence in the measurement method, as you can directly see the results of the particle imaging process.
Data acquisition and interactive image analysis with direct feedback and instant result generation are performed with the powerful **ParticleMaster** software module in **DaVis**.

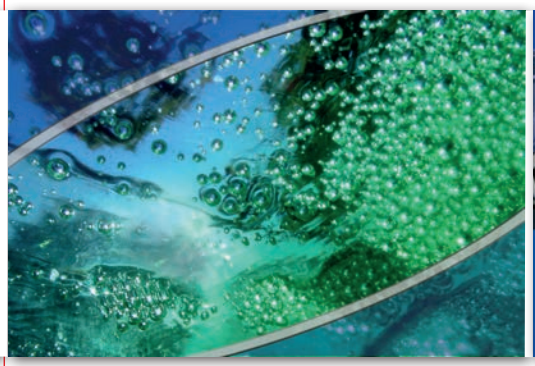
Shadowgraphy

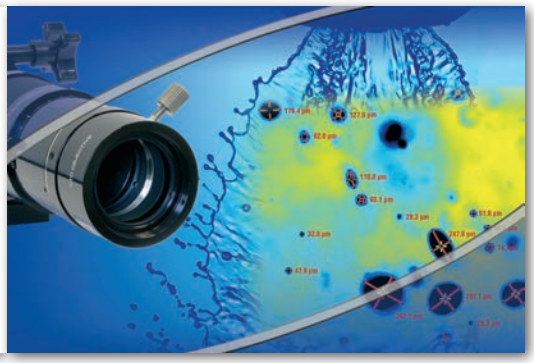
High-magnification shadow Imaging is very suitable for visualizing particles, droplets and other structures. The measurement volume is defined by the camera field of view in the focal plane and the depth of field of the imaging system detecting only focused particles inside this probe volume. The shadow technique is independent of the shape and material (either transparent or opaque) of the particles and allows the detection of sizes down to the micro scale using appropriate optical imaging systems.

Applications

- liquid sprays (fuels, water, paint, pharmaceutical, crop)
- spray break-up and atomization
- powder, solid particles (alloys, ceramics)
- emulsions and dispersions (waste water, meteorology, industrial facilities)
- bubbles (heat exchangers, industrial processes)







System Features

- simultaneous size, position and shape
- particle number density (corrected for different size classes)
- particle velocity derived from double frame exposures
- velocity - size correlations, histograms, scatterplots
- mass flux
- visualization of ligaments, spray break-up and atomization

Specials

LaVision's **ParticleMaster** ***inspex*** system is especially designed for quality control applications in industrial environments. It serves as a highly integrated laboratory and testing tool for the measurement of size, shape and velocity of spray droplets, particles and grains.
The **ParticleMaster** ***inspex*** combines the advantages of high magnification shadow imaging with an easy-to-use design. When particle properties are important process parameters and have to be monitored in real time or inline, our **ParticleMaster** ***inspex*** shadow systems are the right choice.

A customizable remote control interface turns the system into a production line testing tool. Either manually operated or machine integrated operation the interface speeds up testing with predefined operation templates and integrated PDF report generation.

FlameMaster

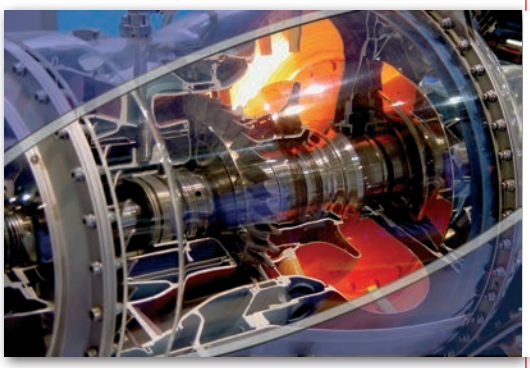
Development of more Efficient and Cleaner Combustion Systems

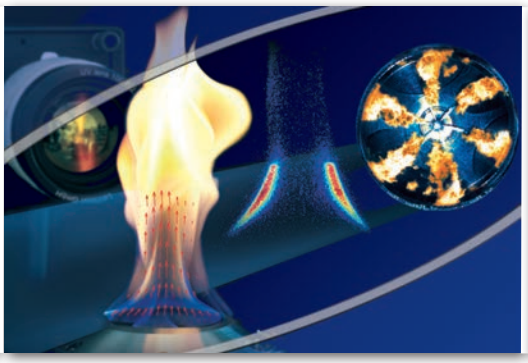
LaVision's **FlameMaster** system family is designed to find new concepts for the realization of more efficient and cleaner combustion devices. These (laser) imaging systems are designed for multi-parameter measurements in all kinds of flames with high spatial and temporal resolution.
Our **FlameMaster** imaging systems support online flame monitoring in industrial devices and provide quantitative information about species (particle) concentration, gas composition and flame temperature in laser-illuminated flame areas. For each imaged combustion parameter a dedicated set of hardware and software modules is provided offering the possibility for straightforward system upgrades. This modular nature for imaging upgrades provides full flexibility for different flame imaging applications.

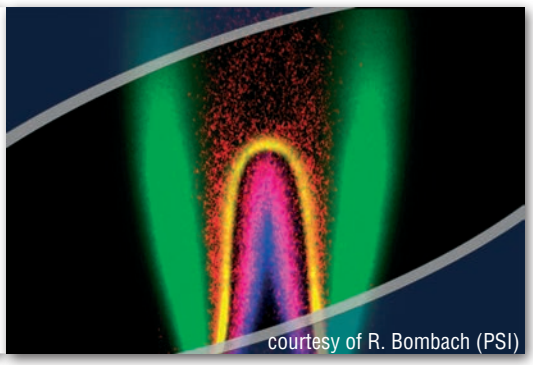
Applications

Investigation of combustion phenomena in

- flames
- burners
- jet engines
- furnaces
- propulsion systems
- chemical reactors
- shock tubes







Information

- fuel LIF imaging, air-fuel mixing
- flame front visualization
- flame radical distributions (OH, NO, CH ...)
- 3D flame structure and flame stability
- flame and soot temperature
- soot concentration and size of primary soot particles
- majority species composition (1D-Raman imaging)

System Features

- integrated turnkey laser imaging systems based on application matched best selection of laser and camera
- complete hardware control using **DaVis** software
- accurate hardware and signal calibration
- flexible beam delivery and sheet forming optics
- laser sheet correction incl. local laser beam absorption compensation
- most efficient LIF excitation technique for each application and flame radical
- spectroscopic data base and background literature
- combination of techniques, multi-parameter laser imaging

SprayMaster

Advanced Spray Analysis

LaVision's **SprayMaster** imaging systems provide information on all relevant spray parameters in even the most complex spray application: complete geometrical spray characterization, liquid (vapor) mass and global droplet size distributions on laser light sheets, multiphase flow fields, mass flux, spray evaporation and propagation. Global spray imaging using extended backlight or light sheet illumination is supported as well as high-resolution imaging of µm-droplets.
SprayMaster systems are easy to operate, fast and efficient measurement tools suitable for R&D as well as quality control applications.

Applications

- characterization and quality control (QC) of nozzles
- inspection of fuel injectors for combustors or IC-engines
- process optimization for industrial painting or coating
- medical / pharmaceutical research: distribution of active ingredients
- more precise application of agricultural substances (e.g. pesticide sprays)

Information

- spray geometry parameters and patternation (symmetry, angle, tip penetration, statistics, break-up length of liquid filaments)
- temporal and spatial spray evolution (time and axis scans)
- local and planar particle (drop) sizing (counting, shape, statistics, number density, size classes: D_{32}, $D_{V\,0.5}$)
- global (3D) spray imaging (digital movies)
- liquid / vapor phase transition, fuel mass distribution
- velocity fields (see **FlowMaster**)
- mass flux measurements (spray impact values)

Specials

Structured Laser Illumination Planar Imaging (**SLIPI**) reduces multiple light scattering applying laser imaging in dense sprays.
SLIPI is based on spatially modulated laser light sheets for Mie or LIF imaging. While multiply scattered light loses the modulation information, it is maintained for singly scattered light. When the stripe-like phase shifted images are combined correctly, the resulting SLIPI image shows higher image contrast and reveals inner spray structures, which are hidden when using conventional planar laser imaging.

FlowMaster

Advanced PIV Systems for Quantitative Flow Field Analysis

Particle Image Velocimetry (**PIV**) is recognized as the most powerful and practical diagnostic tool for flow field analysis in fluid dynamics applications. Instantaneous 2D and 3D flow images are measured with high spatial and temporal resolution. LaVision's **FlowMaster** systems have been generating valuable insights into flow phenomena in scientific, engineering, biological and medical applications for many years. Constant technological advances in hardware and implementation of the latest research of algorithms assure the maximum in performance, accuracy and system operability. Our **FlowMaster** models are application oriented, meeting a wide range of measurement requirements due to their modular and flexible system design.

Applications

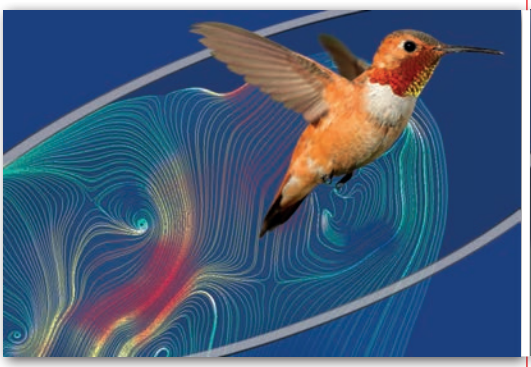
- flow fields in liquid or gaseous flows
- instantaneous velocity maps (microscopic, endoscopic, macroscopic)
- time-resolved flow analysis (up to tens of kHz)
- flow visualization (images or movies or numeric data)

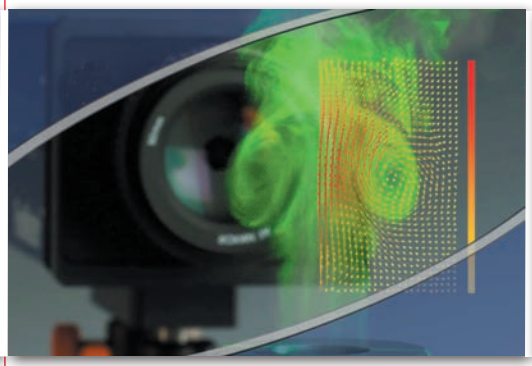
Upgrades

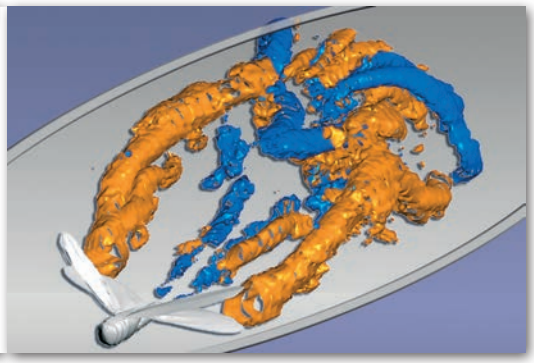
Stereo-PIV

Measurement of all three velocity components inside a light sheet using two cameras based on the principle of two perspective views.

- three velocity components
- patented calibration
- Scheimpflug arrangement of camera optics







Time-Resolved PIV

High frame rate cameras and single- or dual-cavity high repetition-rate lasers capture flow fields at up to tens of kHz frame rate

- fully synchronized recording with LaVision's PTU X timing controller
- pyramid correlation for extended dynamic velocity range
- special algorithms making best use of time-information

Tomographic PIV

Instantaneous 3-dimensional 3-components (3D3C)-vector fields in a complete volume

- special volume optics allows an easy illumination of the desired measurement volume and can be quickly adjusted from thin volumes to large cubes
- any camera setup is possible from standard low-speed cameras to advanced kHz range high-speed cameras
- fully digital recording and processing
- easy calibration, patented Volume Self-Calibration

Specials

Underwater PIV

Modular and flexible underwater setups for several geometries realized with compact vertical borescopes or horizontal torpedoes.

- time-resolved 2D-, Stereo- and Tomo-PIV setups supported
- CFD optimized and tested submarine constructions

Micro-PIV

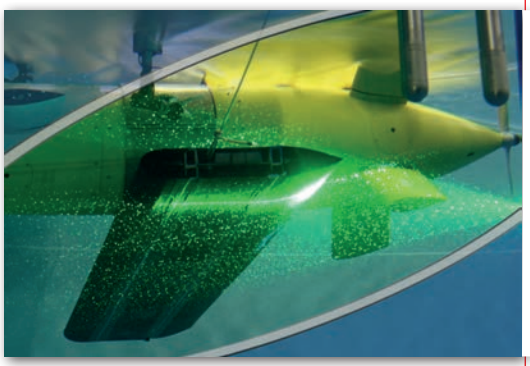
Flow fields in microscopic scales are captured with dedicated combinations of microscope assemblies and illumination solutions. Algorithms optimized for such imaging conditions enable accurate results even for micro-Stereo-PIV applications or tomographic data.

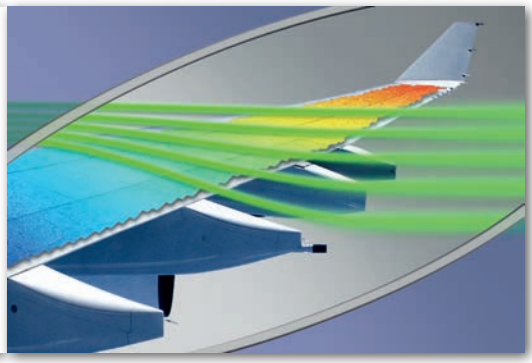
- range of microscopes to select from
- fiber-guided laser beam delivery with efficient coupling
- specific micro-PIV algorithm for enhanced signal-to-noise-ratio

Endoscopic PIV

PIV measurements with only a small hole necessary for the optical access.

- optical distortion correction applying advanced calibration procedures
- camera and laser endoscopes for visible and UV range available
- only holes with 8 mm diameter required
- ideal for IC engines, turbo machinery or pumps





Thermographic PIV

Simultaneous flow field and gas-phase temperature imaging with micrometer-sized thermographic phosphor particles.

- simultaneous single-shot planar velocimetry and thermometry using same tracer particles
- experimental simplicity
- combined phosphor thermometry / velocimetry technique can also be applied at kHz rates

Fluid-Structure Interaction

Combined PIV and DIC technology which simultaneously measure and quantify the interaction of fluid motion and surface deformation.

- study of fluid flow causing deformation of a surface and influence of the surface shape on the flow field
- separate measurements of fluid and structure behavior or simultaneous measurements are possible

FlowMaster

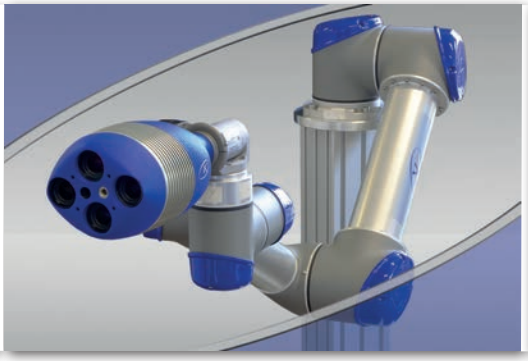
Volumetric Particle Tracking at Highest Seeding Density

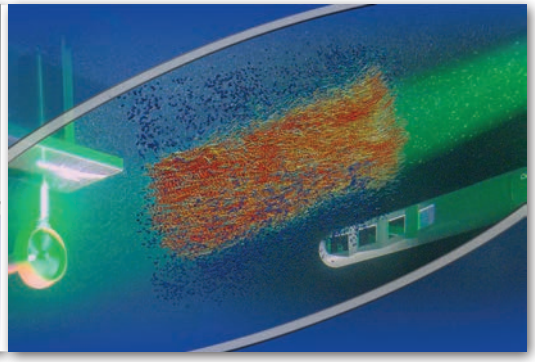
Traditionally **Particle Tracking Velocimetry** (**PTV**) has suffered from a poor spatial resolution due to its limitation of measuring flows with a low particle seeding density. 4D-PTV, as a time-resolved volumetric flow measurement technique, has recently regained a whole new level of attention by the introduction of the award winning "**Shake-the-Box**" method.

Shake-the-Box

This method allows Lagrangian particle tracking at unprecedented tracer particle density and positional accuracy. It is applicable at seeding densities as high as - or even higher than - the most sophisticated volumetric flow measurement systems so far (e.g. Tomographic PIV).

- time-resolved PTV for 4D flow analysis at high seeding densities
- award-winning particle reconstruction and tracking algorithm: 4th International PIV Challenge
- unsurpassed precision for velocity and acceleration of particle tracks
- very fast processing speed
- hardware compatible with **FlowMaster** TR-Tomo-PIV setups





MiniShaker

LaVision's aligned multi-sensor system in a compact housing for quick and easy volumetric flow measurements is available in various models and with adaptable lenses for diverse measurement tasks. With its rigid housing and pre-alignment of the cameras, the compact system is quickly installed and easy to operate for measurements of velocity, acceleration, pressure and turbulence quantities.

- easy installation and operation using a USB 3.0 interface for data transfer
- all models can be optionally equipped with a laser fiber for co-axial illumination featuring air flow measurements even in obstructed volumes.
- a wide range of lenses allows for a quick and easy adaptation to different desired measurement volumes.
- in combination with LaVision's cost-effective **LED-Flashlight** it is ideal for measurements of water applications
- mounted to a robotic arm and combined with **Helium-filled soap bubble** (**HFSB**) seeding, the flexible system is most appropriate for large-scale flow analysis

Another model, the **MiniShaker Underwater,** a very compact, watertight multi-camera system ideal for time-resolved volumetric PTV (Shake-the-Box) and Tomographic PIV measurements in underwater applications, is available as well.

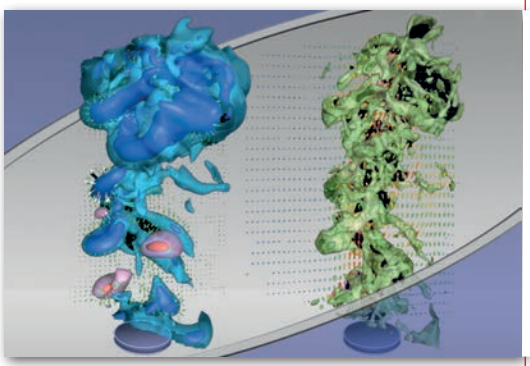
Specials

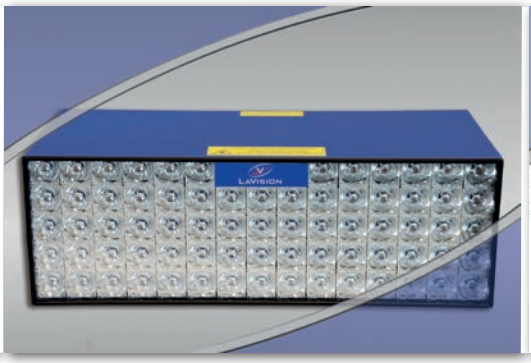
Pressure from PIV

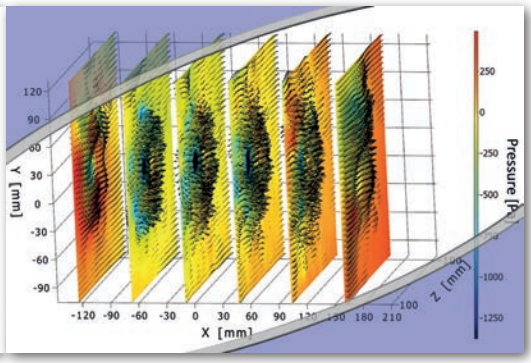
The new **Pressure from PIV** software package meets the strong demand for direct extraction of full 3D and 2D pressure fields from PIV and **Shake-the-Box** (4D-PTV) data. With only a few clicks, **Pressure from PIV** together with LaVision's **DaVis** software retrieves and visualizes average pressure fields from all kinds of PIV and PTV velocity data either imported to or directly computed by **DaVis**. For time-resolved data, even the instantaneous pressure can be evaluated.

- non-intrusive, direct method for pressure retrieval in complete volumes
- pressure calculation from PIV/PTV measurements

A new **4D Pressure Solver** was developed by LaVision for instantaneous pressure fields, which yields stable and reliable pressure results. It frees the user from limitations on the shape of the test domain. The central idea of this pressure solver is to utilize the temporal information enforcing temporal continuity. Also the requirements of user-defined boundary conditions are minimized.







Fine Scale Reconstruction

This new data assimilation technique combines measured track data with the laws of fluid dynamics. The **Fine Scale Reconstruction** converts particles tracks from Shake-the-Box results to flow field data on a grid with an unsurpassed quality and spatial resolution by using the advanced Vortex In Cell (VIC#) approach.

- convert Shake-the-Box data to Eulerian data
- provide unsurpassed quality and spatial resolution
- use laws of fluid dynamics (Navier-Stokes equation, vorticity transport equation, incompressibility constraint) for data assimilation
- calculate pressure along with velocity and acceleration

PIV Uncertainty Quantification

As with all measurement techniques, it is important for PIV to estimate the associated errors (uncertainties) for individual computed velocity vectors as well as for derived quantities. LaVision has implemented an uncertainty quantification method based on correlation statistics, being able to provide an uncertainty value for individual instantaneous velocity vectors for planar 2D- and Stereo-PIV and derived values such as avg, stdev, TKE, vorticity, Reynolds-stresses etc. The method is universal and works for all processing parameter settings in **DaVis** and comprehensively captures error sources included in recorded PIV images.

FluidMaster

Imaging of Mixing Phenomena in Fluids

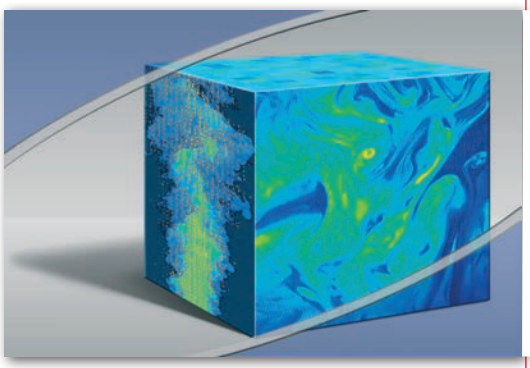
LaVision's **FluidMaster** laser imaging systems measure scalar flow properties such as concentration, mixture fraction, fluid composition and temperature in various fluid dynamical applications. For scalar laser imaging in fluids **Laser Induced Fluorescence** (**LIF**) is the most versatile and practical measurement technique featuring high signal levels and spectral selectivity.

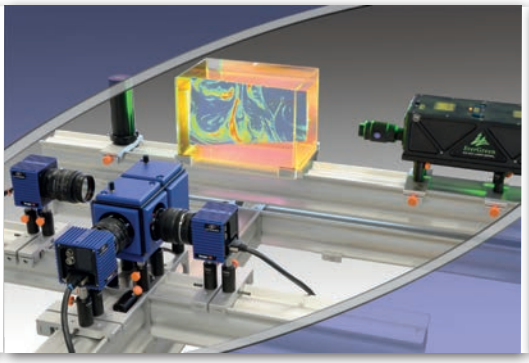
Applications

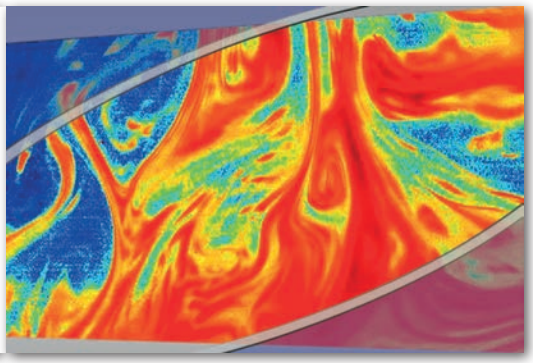
- high-resolution imaging of the mixing process
- high-speed imaging to study process dynamics
- monitoring of reactive mixing processes
- microscopic imaging of small-scale mixing structures
- thermometry in non-reactive fluids

System Features

- integrated turnkey laser imaging systems based on application-matched best selection of laser and camera
- complete hardware control using **DaVis** software
- accurate hardware and signal calibration
- most effective LIF excitation techniques
- Rayleigh thermometry package for thermal gas flows







Specifications

- non-intrusive and fast on-line mapping of concentration fields
- high spatial resolution (more than 5 million measurement points)
- high performance, photometric imaging systems
- high-speed image recording up to several tens of kHz
- light sheet and image correction, intensity calibration
- movie presentation of transient mixing processes

Information

- instantaneous digital concentration fields with statistics (mean and rms values)
- visualization of large- and small-scale mixing structures
- degree of mixing
- reactive mixing: reactant and product visualization
- flow field visualization

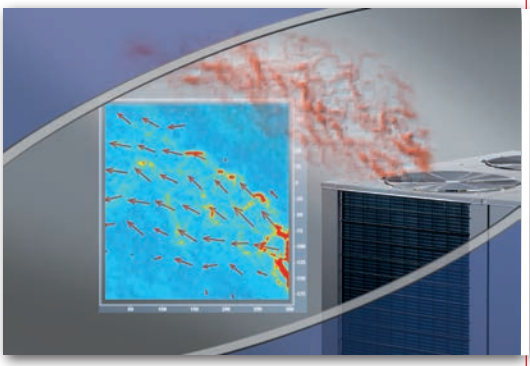
Gas Motion Visualization

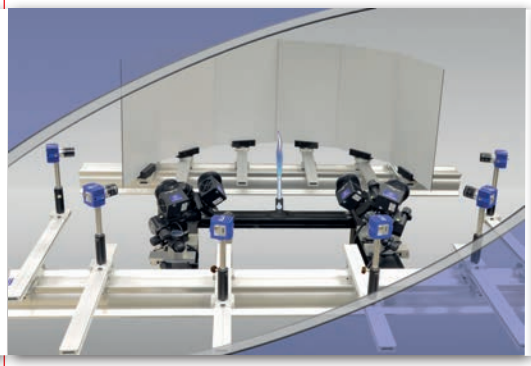
For the visualization of gas motion based on local refractive index variations **Background Oriented Schlieren** (**BOS**, also known as Synthetic Schlieren) is a simple and cost-effective alternative to laser imaging methods, because it doesn't need any complex illumination device like a laser and it works without seeding the flow.

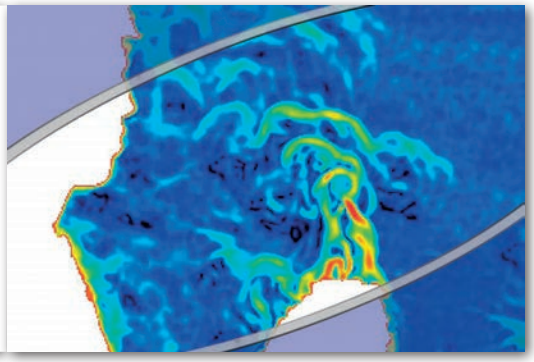
BOS is a line-of-sight imaging technique and measures locally the density gradient as an integrated value. In practice, a random dot pattern in the background of the flow is imaged with a high-resolution camera before and during the test. By comparing the two pictures (or more precisely correlating the two patterns similar to the image correlation in PIV) the local displacement of the background pattern can be used to provide lateral information on path-integrated refractive index variations.

Applications

- localization of eddies, vortices and Schlieren
- mixing of gases and liquids
- thermal flows and flame temperature
- sound and shock waves
- gas leakage detection







System Features

- simple flow visualization technique without laser and flow seeding
- advanced image correlation technique applied on background target
- BOS software module in **DaVis** for quantitative density (temperature) imaging in 2D and axisymmetric flows

Specials

LaVision's **FluidMaster Tomographic BOS** imaging systems measure quantitatively density or temperature fields in 3D using multiple camera BOS projections. This 3D imaging technique requires an accurate geometrical calibration of the multi-camera system and an iterative tomographic reconstruction algorithm.

- instantaneous 3D temperature (density) fields
- flexible multi-camera setups
- high-speed tomographic BOS imaging for time-resolved measurements

EngineMaster

Diagnostic Tool for better Engine Design

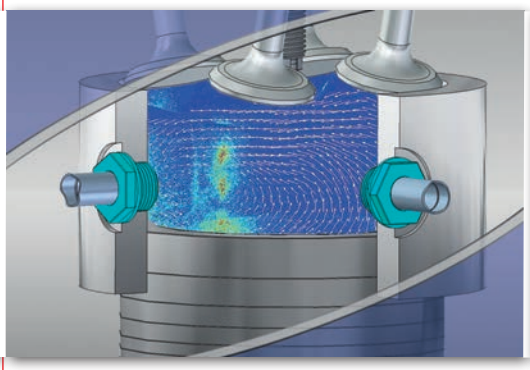
LaVision's **EngineMaster** laser imaging systems provide information on fuel injection, mixture preparation, pre-combustion, flame species, NO formation and soot production. In-cylinder flow fields are measured with our **FlowMaster** systems. Crank angle resolved in-cylinder laser imaging is performed on pulsed laser light sheets in optical engines or by keyhole imaging using minimal invasive endoscopes.

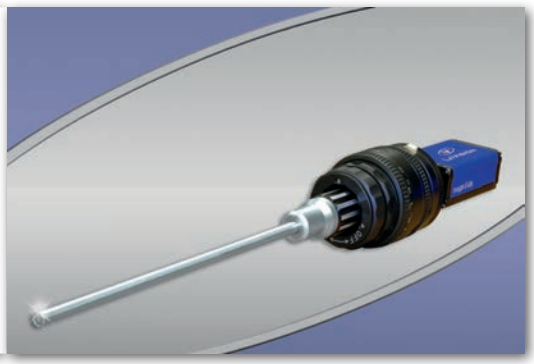
Applications

- fuel injection
- air-fuel mixture preparation
- in-cylinder temperature fields
- ignition and flame propagation
- pollutant and soot formation

Information

- liquid and vapor fuel concentration fields
- local air/fuel ratios (lambda-maps)
- in-cylinder temperature during mixture formation
- flame front propagation
- combustion species concentration (OH, NO, CH ...)
- soot concentration and primary soot particle size





System Features

- integrated turnkey laser imaging systems based on application-matched best selection of laser and camera
- complete hardware control using **DaVis** software
- accurate hardware and signal calibration
- pre-defined crank angle resolved measurements with cycle statistics
- multi-functional engine synchronization interface: crank angle decoder, engine simulator, trigger conditioner

Specials

- endoscopes for keyhole imaging
- high-speed digital film recording of complete cycles
- high-speed imaging pyrometers

Internal Combustion Optical Sensor (ICOS)

Characterization of In-Cylinder Processes

The **Internal Combustion Optical Sensor** (**ICOS**) from LaVision provides a measurement technique for highly time resolved gas analysis directly in the combustion chamber of internal combustion gasoline, gas or diesel engines. Highly time-resolved data of the relevant engine parameters air/fuel-ratio and CO_2-concentration are recorded and visualized in detail. This allows an analysis of dynamic variations for hundreds of consecutive cycles.

The optical system is based on infrared absorption spectroscopy and measures relevant molecules like CO_2 or hydrocarbons. The **ICOS** system detects the specific absorption of infrared light by these molecules. It measures directly inside the cylinder and therefore the system is contactless and no gas sample extraction is needed.

Applications

- for gasoline and diesel engines
- air/fuel-ratio - lambda value (λ)-transients
- investigations of highly dynamic engine conditions, e.g. cold start
- capable of verifying injection strategies and valve timings
- internal and external EGR rates
- exact analysis of the EGR stability
- distribution of EGR between different cylinders

Advantages

- ultra-fast response time
- crank angle resolved data
- no gas sampling, measures directly inside the cylinder
- unmodified engines, real fuel
- precise single cycle analysis
- fully resolved consecutive cycles for measurement on transient phenomena

Specials

The **ICOS-CNG** systems provide an ultrafast measurement tool to analyze the crank angle resolved in-cylinder air/fuel-ratio evolution of compressed natural gas (CNG) engines. The mixture formation and the degree of homogeneity is easily visualized.

The **ICOS Temperature** systems allow analysis of time-resolved in-cylinder temperatures and water concentration in an internal combustion engine. Both parameters are invaluable for the evaluation of different injection strategies.

Standard Cameras

Intelligent imaging starts with an intelligent selection of the best possible camera matching a given application. Since different camera models from different suppliers can be distinguished by different advantages we test and qualify each new device with our extensive in-house knowledge and strict criteria so that we can offer best imaging configurations.

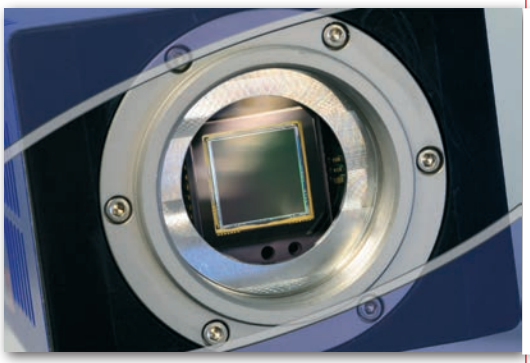
Photometric Cameras

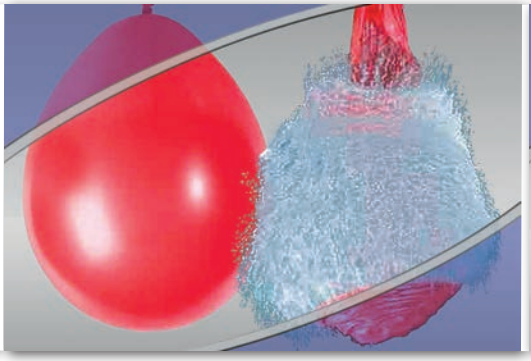
Imager camera family

The **Imager camera family** consists of the widest range of models to be found at any imaging systems supplier. No matter if highest priority is on spatial resolution, frame rate, sensitivity, weight or price there is always a solution in our portfolio.
These advanced progressive scan cameras with extremely short interframe times for PIV are accompanied by camera series for applications which do not require double-frame images. Variations with CamLink, GigE or USB interfaces and selectable bit depth of the digital signal add to the number of cameras to select from.

Imager *sCMOS* camera

The **Imager *sCMOS*** camera contains a new generation of scientific CMOS (sCMOS) sensor and combines the advantages of modern CCD and CMOS sensor technologies resulting in an unsurpassed image quality and system performance. The high-resolution 5.5 million pixel **Imager *sCMOS*** camera with extremely low readout noise and high frame rates offers excellent imaging performance in the field of quantitative scientific (laser) imaging. The high dynamic range of the camera makes it ideal for many applications like PIV and LIF.





High-Speed Cameras

Photron & Phantom camera families

For applications requiring extreme frame rates or high-speed image acquisition the CMOS cameras are the perfect solution. Modern technology enables an ever-increasing maximum frame rate: full sensor resolution up to 25 kHz of full images and up to 1 MHz for smaller image windows are currently available.

The **Photron FASTCAM** and **Phantom** series cameras are fully characterized for image quality, noise and trigger capabilities in details the manufacturers do not have on their datasheets.

Specialized models are the **Imager HS 4M** cameras with best image quality and 4 Mpixel resolution, while the **Imager *MX* 4M** camera covers mid-speed frame rates.

Intensified Cameras

Modular, Lens-Coupled Intensifier Units

Lens-coupled Intensifier IRO X and High-Speed (HS)-IRO X

Image intensifiers usually find their use in situations when a weak light signal is to be amplified or when a short exposure time requires a fast gating or simply when UV sensitivity needs to be added to standard cameras.
Our **IRO X** and **HS-IRO X** intensifiers are supporting the repetition rates of standard cameras and high-speed cameras, respectively. Both can be equipped with second or third generation intensifiers and different phosphor screens.

- lens coupling for optimized image quality
- fast phosphor decay times for high-speed applications
- camera remains available for applications without intensifier

Integrated ICCD Camera

NanoStar

LaVision's **NanoStar** cameras couple optically a 25 mm high-resolution image intensifier with an outstanding high-efficiency tandem lens system to a 16 bit sCMOS sensor. Camera Link HS, the latest standard of high-performance data interfaces for scientific cameras, guarantees uncompressed and robust 16-bit data transfer via optical fiber over virtually any distance.

- lens coupling for optimized image quality
- 4 ns minimum exposure time
- 2048 x 2048 pixel sCMOS sensor

ICCD Camera System

PI-MAX4®

The **PI-MAX4®** ICCD camera systems are featuring a 1024 x 1024 interline CCD sensor fiber optically coupled to a variety of intensifiers covering the spectral range from UV to NIR. Fiber coupling with highest throughput is realized without vignetting. GigE interface supports fast data transfer over distances up to 50 meters.

- fiber coupled 18 mm intensifier to CCD sensor
- 3 ns minimum exposure time
- 1024 x 1024 pixel interline CCD
- 26 fps @ 16 bit and full resolution
- GigE data interface

System Components
for Optimized Performance

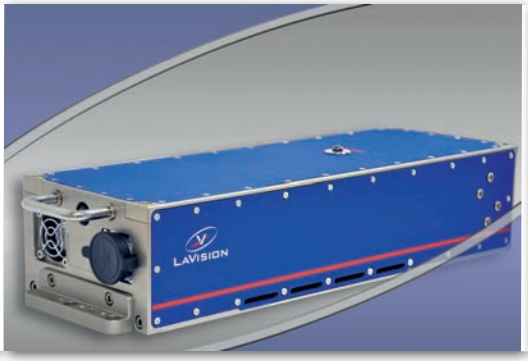
Any part of an imaging system is decisive for the combined performance. So instead of simply bundling accessories we use either properly selected system components or we thoroughly design them ourselves. The optics, mechanics and electronics which turn individual devices into a system shall make the user's work not only more accurate and efficient but also enjoyable.

Lasers and Light Sources

- a wide range of shuttered cw lasers designed to provide a highly stable light source, ideally suited for micro-PIV and even high-speed PIV experiments
- high repetition rate laser for mid-speed PIV and time-resolved PIV applications
- a huge range of dual-cavity solid state lasers for PIV
- high and low repetition rate pulsed dye lasers for combustion research and flame characterization
- a series of high-pulse energy Nd:YAG lasers for e.g. pumping of dye lasers
- flashlamps with ultra-short flash duration for high-speed requirements
- various LED illumination units for strain and deformation analysis and high-speed imaging to be used in constant or pulsed mode

Laser Accessories

- laser endoscopes with full range of optics for visible and UV wavelengths for planar laser light sheet illumination inside cavities
- several fiber coupling devices for a flexible and robust optical coupling of laser light enabling flexible setups
- light sheet optics, special sheet optics, light guiding arms, collimators and telescopes for beam guiding and light sheet formation
- several devices for the control of laser pulse energy and polarization



Camera Accessories

- various camera endoscopes enabling measurements in areas with minimum requirements for optical access
- numerous filters for signal separation and background or cross-talk suppression but high transmission
- Scheimpflug mounts for an easy manual or remote Scheimpflug angle adjustment
- camera lenses and long-distance microscopes to adjust to any condition of working distance and magnification at the desired resolution
- special lenses for highly effective image capturing in the UV range
- beamsplitter devices enabling imaging of different optical signals with identical beam paths
- double image projection for spectral separation of incoming light with LaVision's Image Doubler
- laser shutter and online-energy monitor for stable and safer use of UV lasers

Calibration

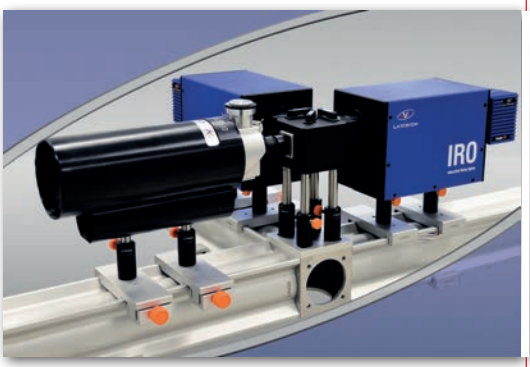
- two-level calibration plates with extremely tight tolerances so that a spatial calibration with a single view and no need for moving the plate gives a superior accuracy
- micro calibration plates for calibration purposes with small scale fields of view, especially for micro-PIV applications
- a depth-of-field calibration set for increased accuracy in particle size measurements by Shadowgraphy or other applications that use a high magnification
- our calibration burner with known flame species concentrations and temperatures

Mounting

- a variety of rail and tripod mounts for small as well as large cameras and lasers assuring comfortable handling of cameras while providing the required ruggedness and stable, vibration-free operation during measurements
- customized or standard modular traverse systems with high-resolution positioning and high stiffness traverse mechanisms are available in configurations of 1 to 4 axes with strong motors for high loads

Triggering

- additional to our unique synchronizer Programmable Timing Unit (PTU) which can create flexible trigger sequences that would otherwise require a long cascade of simpler timing boxes we designed trigger conditioning and trigger logic devices to adapt to any complicated application requirement



Seeding

- several models of gaseous, liquid and solid tracer particle generators
- diverse kinds of seeding particles for any type of application

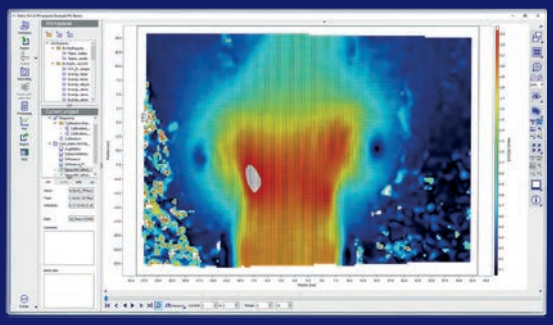
Services

- customized software solutions
- contract measurements
- customer LIF and PIV seminars
- equipment loan
- on-site demonstrations and feasibility tests
- inline / online quality control systems and
- flexible and customized optical measurement solutions

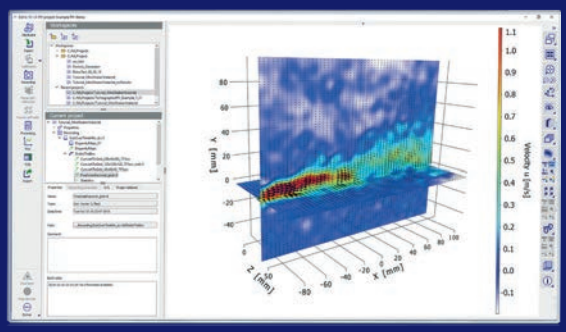
DaVis Software

Powerful and Versatile Software Package for Data Acquisition and Visualization

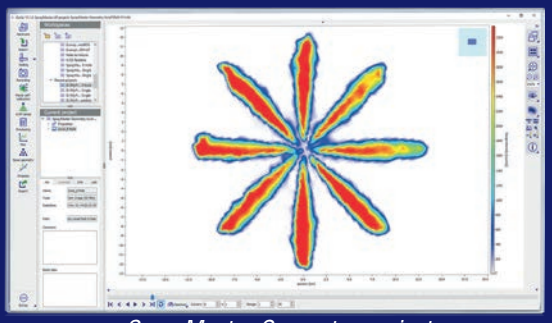
All LaVision Intelligent Imaging systems are driven by our powerful and comprehensive software for data acquisition, visualization and processing. **DaVis** runs under 64 Bit Windows and offers a wide range of application specific modules.



DaVis Project Manager



MiniShaker project



SprayMaster Geometry project

Features

- very flexible and versatile data acquisition and device synchronization, including synchronization to external events, user defined trigger lines, multi-camera and multi-laser support
- 2D and 3D visualization of data, especially for vector fields (PIV) with a large variety of presentations for vectors, their derivatives and raw images
- statistics on image data, vector fields and its derivatives
- processing speed-up by use of multi-core CPUs and GPUs
- large library of built-in processing and filtering functions, which can be extended by yourself using our open data access model
- data import and export from and to several image and numerical formats (AVI, TIFF, PNG, Tecplot®, ASCII, …)
- data management in application specific projects
- free lifetime support and upgrades within a major release over many years
- **customized macros and programming services on request**

Open Data Access

- write your own processing functions with the integrated macro language
- take advantage of existing routines of the image processing library to analyze your data
- get access to your data with our free MATLAB® add-on, running under Windows®, Linux® and Mac OS®
- generate stunning 3D visualization of **DaVis** data using our free add-on for Tecplot®
- implement your own DLL: we supply a free C++ library and sample code to grant efficient access to **DaVis** data in your own complied code

DaVis Software

Device Control
CCD & CMOS cameras, intensifiers, Image Doubler
remote controlled focus, Scheimpflug, polarization
PIV lasers, cw lasers, dye lasers, flash lamps, LEDs
Programmable Tming Unit (PTU)
A/D converter
Energy Monitor, shutters, user specific triggers
traverses (x,y,z rotation), microscopes

Data Acqusition and Visualization
application specific projects
device synchronization and data recording
data browser with 2D and 3D visualization
camera calibration
import / export
Tecplot®, MATLAB®, Labview, C++ add-ons

Data Processing
filtering, smoothing, thresholding, FFT
image mapping, dewarping, scaling
statistics: average, stdev, min, max, pdf
spacial and temporal plots
user programmable functions (macro, DLL, MATLAB®)

Flow Field PIV | **Materials Testing** | **High-Speed** | **Spray** | **Engines** | **Combustion** | **Particles** | **Tunable LIF** | **Rayleigh/ Raman**

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