StrainMaster µDIC

Micro-Scale Measurement of
3D Strain, Displacement and Shape

LAVISION
FOCUS ON IMAGING

StrainMaster µDIC

Technology for Small Scale, Full Field Strain Measurement

StrainMaster from LaVision combines the most advanced **Digital Image Correlation** (**DIC**) algorithms with the highest quality hardware to provide a complete system for materials analysis. **StrainMaster µDIC** systems use advanced imaging optics and illumination to unlock measurement capabilities at the micro scale.

Complete micro-DIC system on moveable cradle

StrainMaster µDIC can be supplied as a complete turn-key system or as stand alone software for importing and processing images from an external source such as a Scanning Electron Microscope (SEM).

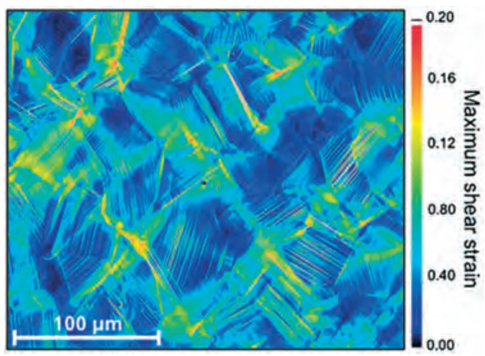
As a complete system it comprises all necessary hardware, and the software has complete control of the connected devices.

The software includes data management, image acquisition configuration, data processing and validation, display and export of information. LaVision‘s approach to image correlation means that all of the pertinent information is visible and the user chooses the level of post-processing within the software.

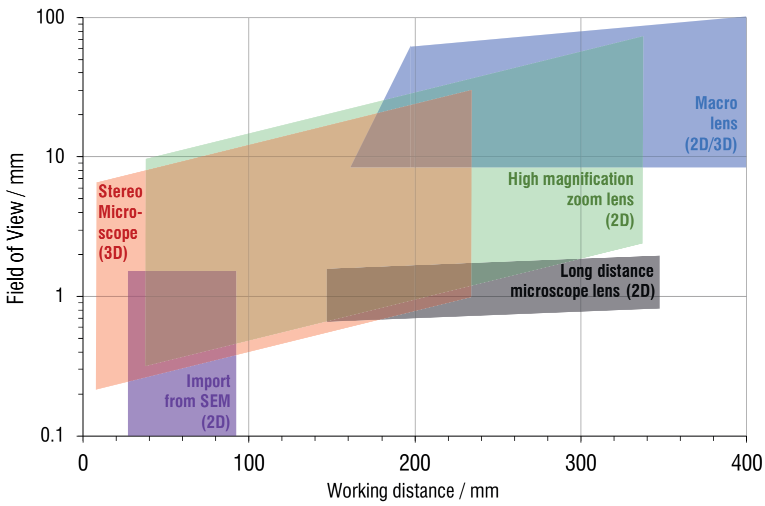
There is no need to use third party software, and using one software platform for all functionality ensures users can focus on optimizing their experiments rather than spend time learning different pieces of software.

Turnkey systems can be configured with LaVision‘s complete range of cameras depending on the strain rate of the test (or the frame rates desired), and the resolution of the chip. Cameras capable of frame rates from 8 Hz up to 300 KHz are available, and resolutions between 1 Mpix up to 29 Mpix.

LaVision’s extensive camera range can be paired with a wide range of lens systems. Additionally images can be imported from high magnification sources such as SEM, thus providing a versatile range of Fields of View and working distances, as illustrated in the graph below.



Revealing strain at grain boundaries from SEM images



Measurement areas covered by LaVision’s µDIC systems plotted against working distances

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Low Cost System Configuration

Where a test is to be conducted to look at strain development on a flat surface, often a one camera 2D system will be capable of producing the data required. The main advantage of these configurations is their simplicity and low cost.

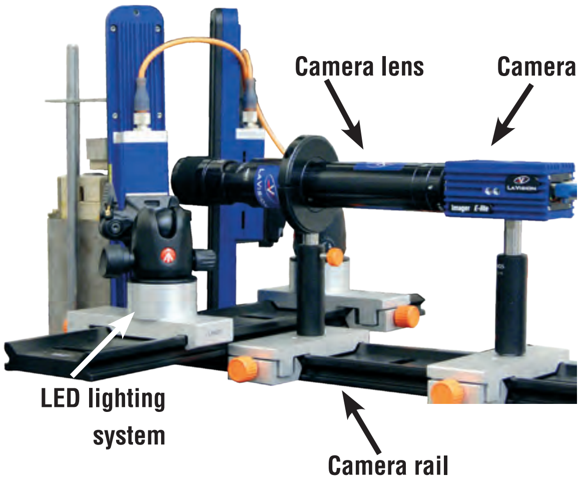
LaVision has a selection of cameras with small pixels which are well matched for micro-DIC applications. High pixel density and small chip configurations mean simple macro lenses with a 1:1 magnification can already begin to unlock some of the powers of a µDIC setup at minimal costs.

The M-lite 5M camera has 3.45 µm pixels and a 5.1 Mpix chip configuration – ideal for micro-DIC

Zoom Lens Example Magnifications

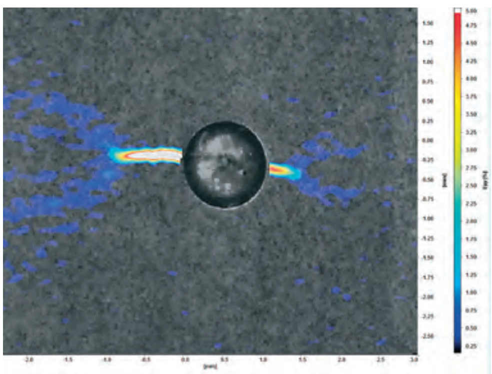
Where better resolution and higher magnifications are required but the working distances from the object are not restricted, a high magnification zoom lens (shown right) can provide excellent image quality.

- 3.5x magnification at 341 mm working distance
- 28x magnification at 37 mm working distance



In some circumstances the lens system cannot be placed so close to the sample surface and as such a Long Distance Microscope lens system can be used.

Working range:
QM 100 • 15 - 35 cm;
QM 1 • 56 - 170 cm



Crack initiation at 250 µm corrosion pit under fatigue loading

2D microscopes with significant zoom capabilities in the body and very high optical resolution can also be used in combination with various cameras; mounted either vertically or horizontally to allow greater flexibility when setting up and focusing the system on the desired area of interest. The image here shows a high-speed camera and microscope combination.

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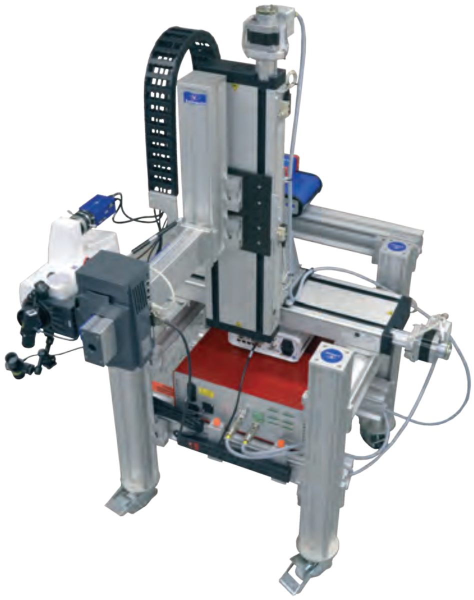
Elimination of Errors caused by Misalignments

Stereo microscope based DIC system investigating fatigue crack growth



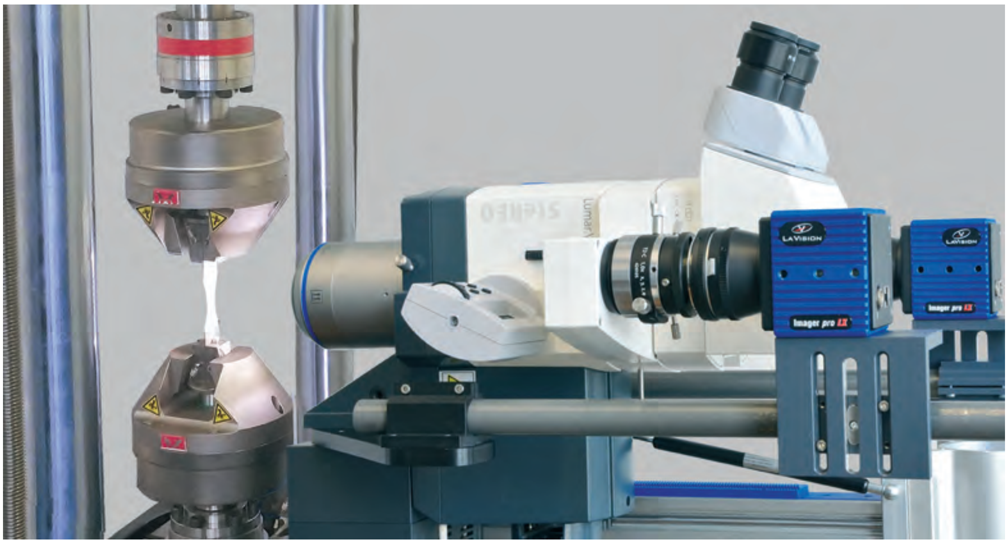
Translation stages for micron accuracy positioning

Whenever the surface to be studied is not completely flat, a stereo 3D DIC system should be used. Even when working with flat samples a stereo 3D configuration can offer significant benefits over 2D. For example, when loading a flat faced sample and measuring displacements and strain with a single camera it is important that the loading direction remains perpendicular to the camera.

Any movement of the sample towards or away from the camera cannot be quantified by single camera setup, and as a result may appear as artificial displacements and strains. With a 2 camera setup any slight misalignments or off-axis movements are measured and, therefore, that error source is eliminated. During µDIC experiments it is often very difficult to constrain sample displacements to be perfectly in one plane only, and even small misalignments on the µm scale can show up as errors in a measurement. As a result LaVision would always recommend a stereo setup.

LaVision's stereo µDIC systems are a modular upgrade from the 2D systems, but now using 2 cameras and a modified stereo microscope body and lens system.

The systems can be configured to be in a vertical orientation, where bench top testing is possible, or as a horizontal mounting where the system is to observe traditional UTM/cyclic type testing.



In addition to custom mounting arrangements systems can be configured with 1-3 axes of motorized translation, allowing motorized control of the area of interest and the focal plane. When working at the µ-scale fine control of these parameters becomes very important and LaVision's tried and tested configurations can save users hours in setup time.

A wide range of objectives are available and can be selected for maximum magnification (with short working distances), or longer working distances (but lower magnification). The latter is often required where the presence of grips or heated/chilled chambers restricts the minimum working distance.

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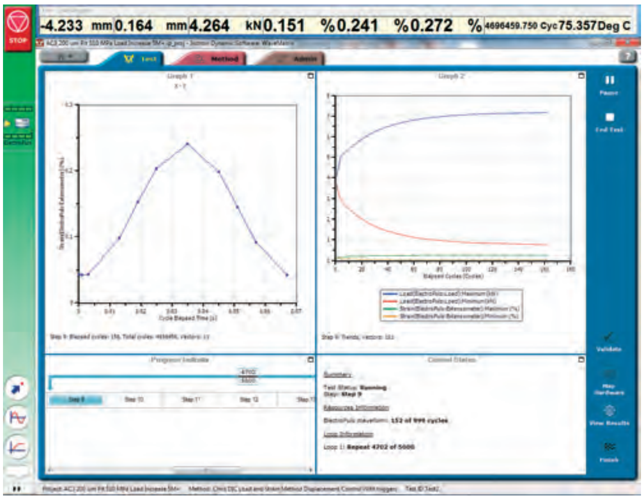
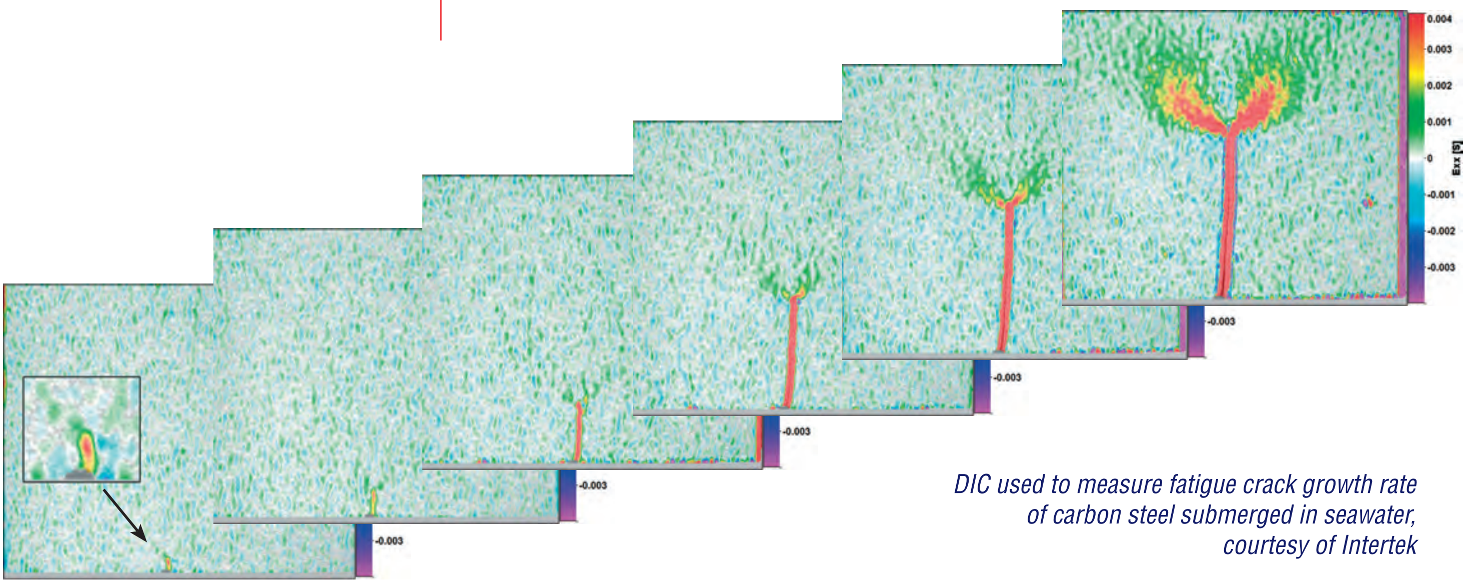
Quick and Simple Configuration of the System

LaVision‘s flexible **Device Control Unit X** synchronizes the cameras and lighting together using stable and accurate hardware generated triggers. All the timing options are controlled from within the **DaVis** software, meaning the user can setup and configure the system quickly and simply requiring minimal parameter input.

Often there will be a test machine driving the loads which are imparted on the sample. LaVision‘s system can be configured to trigger images at various points in the loading cycle. The decision about when to trigger images can either be made by the **Device Control Unit X** or the test machine control suite (such as Instron‘s Waveform software – shown here).



The control unit can accept a wide range of analogue data signals from other devices such as loads, displacements, temperatures and pressures. All the logged data is stored with the relevant images and can be used to plot various fundamental characteristics such as stress/strain curves.



DIC used to measure fatigue crack growth rate of carbon steel submerged in seawater, courtesy of Intertek

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Great Variety of Illumination Options

Pulsed laser and fiber bundle delivery system

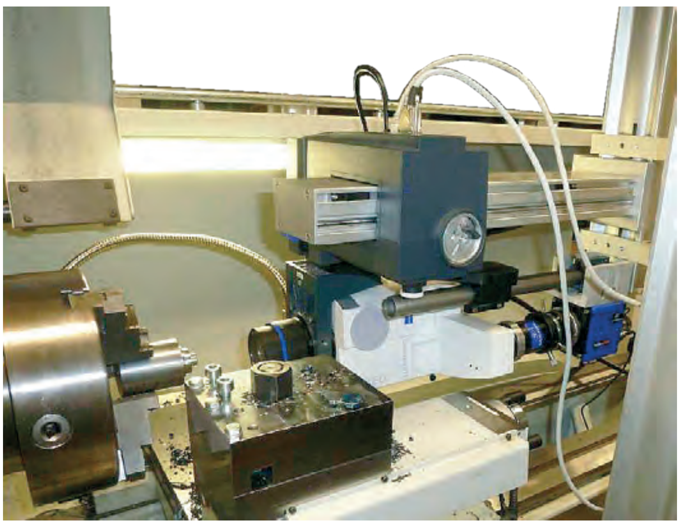
When imaging at high magnification the levels of light reflected back to the camera sensor are often lower than for a standard macro setup, and working distances can often be very small. For this reason LaVision offers a number of different illumination options which can be selected to fit with the experiment.

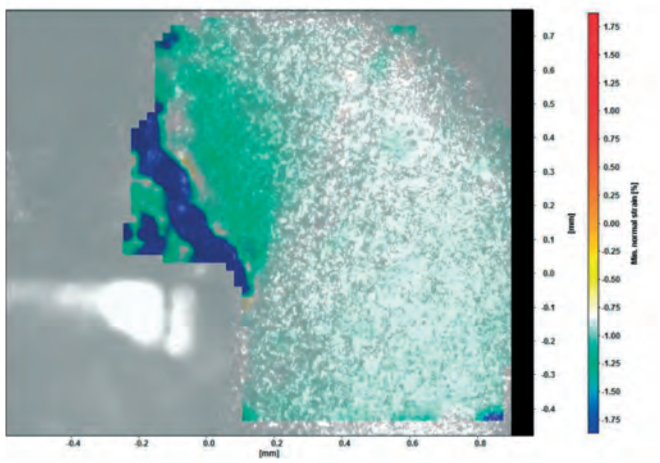
Where working distances are not significantly restricted and optical access to illuminate the specimen is good, LaVision‘s linear illumination units offer a very flexible solution. The illumination can be in either white light for standard testing or blue light to be paired with cut-off filters on the cameras for high temperature testing.

From within the **DaVis** software the chosen lighting solution can be setup to give either a constant or a pulsed illumination. Running in pulsed mode also offers the opportunity to ‚overpulse‘ the LEDs to give the maximum potential light output.

Where working distances are restricted or optical access is limited LaVision can provide small, divergent or collimated illumination units. Both units can also be run in a pulsed or constant illumination mode and their compact form factor allows them to illuminate sample surfaces even when optical access is restricted by either the microscope objective, or narrow windows in test chambers.

For applications where the object surface deforms or moves very quickly across the small field of view used in µDIC experiments, a nanosecond pulsed laser can be used. The short pulse length of the laser ensures image blur is avoided by effectively freezing the motion within the exposure time of each frame. Often this illumination configuration is needed when looking at machining applications such as that shown below.





High-speed metal cutting application

Testing in Challenging Environments

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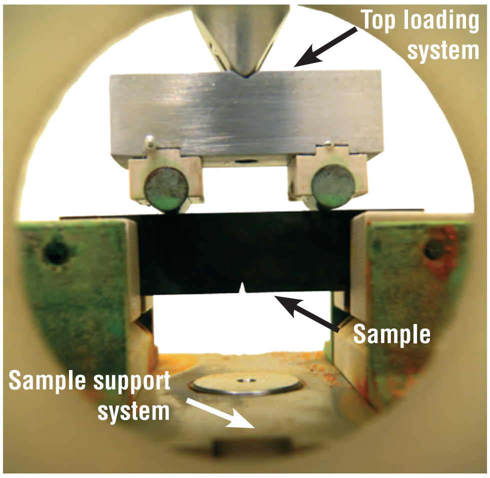
Solutions for Difficult Optical Access

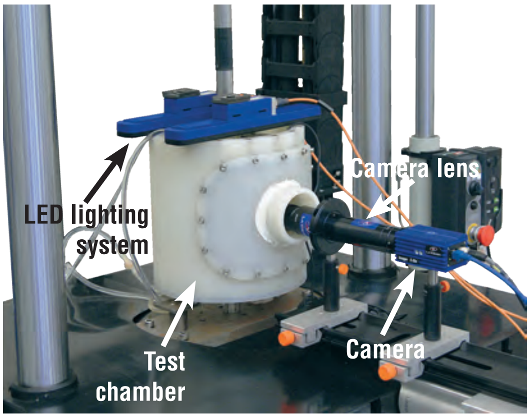
Part of the appeal of using a DIC system is that it can measure strain on surfaces where traditional strain gauging becomes difficult. Some examples include submerged samples, or testing at elevated temperatures. In these environments the normal strain gauge will not survive, and even if it could survive, access to the sample for a mechanical extensometer will be extremely difficult.

In these cases the sample is often housed in some form of chamber where optical access can be difficult. However, providing there is some form of optical access it will normally be possible to achieve successful DIC.

In the case of heated chambers we are able to combine appropriate lighting and filters to avoid the infra-red glow from the surface contaminating the image quality, and thus maintaining good accuracy.



Fatigue testing of steel, courtesy of Intertek

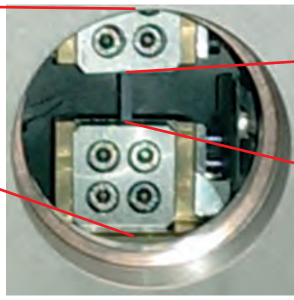


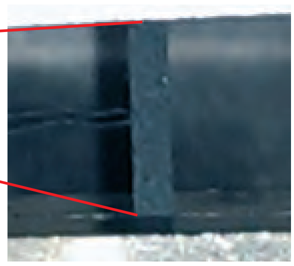
Fatigue testing of submerged steel, courtesy of Intertek

The LaVision software incorporates special calibration modes to account for strong optical distortion and, therefore, even where there is a thick window or the sample is in solution, we are able to deal with this and still acquire high quality data.

In high temperature environments, the DIC system is able to obtain invaluable information about the strain evolution with time, and through a microscope setup identify very small scale effects.

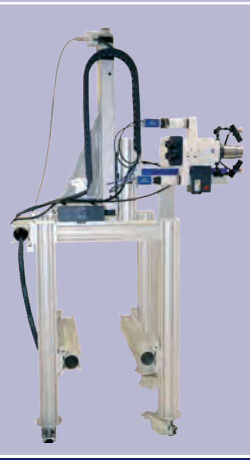
Testing of aerospace alloys using resistance heating, courtesy of AFRC Strathclyde





This brochure outlines the wide range of micro-DIC systems available for studying strain and deformation at very small scales. Please contact LaVision to discuss your material testing requirements.

Microscope Support Frame for Horizontal Viewing

Support Frame	Model	Features
	**1109826**	Fixed cradle with extremely compact footprint of 50 x 45 cm, no wheels, to operate the microscope horizontally in a working height of 25 - 150 cm from ground level which can also be customized if required, no fine adjustment of working height, for setups without motorized translation units, for small cameras (M-lite).
	**1109830**	Cradle with retractable wheels and a footprint of 75 x 60 cm, to operate the microscope horizontally in a working height of 40 - 190 cm from ground level (with 1 m translation unit), which can also be customized if required for use with motorized translation units (50 cm), for small cameras (M-lite).

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