StrainMaster Portable

Full Field Measurement and Characterization of
Materials, Components and Structures

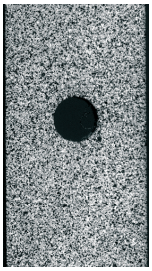
LAVISION

FOCUS ON IMAGING

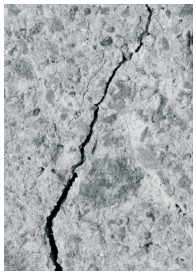
Whole Surface Measurements

StrainMaster systems are based around the technique known as **Digital Image Correlation** (**DIC**), which utilizes images taken using advanced CCD and CMOS Cameras of the material or component undergoing some sort of loading process. This is a non-contacting optical technique – as long as the surface is visible we are able to acquire images.

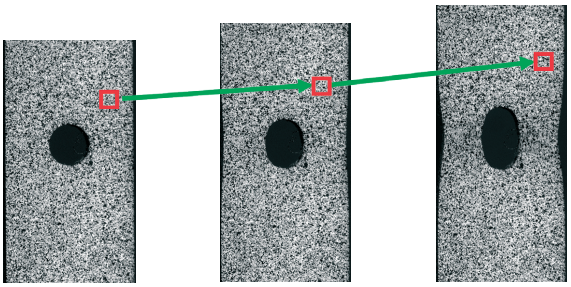
Surface Pattern



The optimum pattern for the technique is a random, rich in contrast, speckle pattern which is typically created with standard aerosol paints. In some cases the natural surface pattern may be suitable (e.g. concrete).



By following the surface pattern, local surface displacement can be calculated everywhere, and a whole field map of the displacement and strain can be calculated.

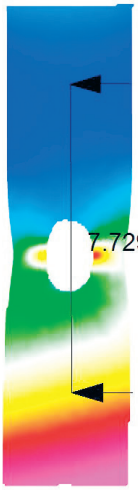


The pattern (which can be natural, or applied) is tracked all over the surface of the imaged material. By following the pattern everywhere the local displacement is calculated.

StrainMaster versus Traditional Techniques

The technique offers several advantages over traditional approaches such as strain gauges and mechanical extensometers:

- high data yield (multi-point information)
- no need to know where to place the gauge before the test starts
- does not damage the surface through mechanical attachment
- identify local hot spots, discontinuities, and cracks
- works in hostile environments such as solutions and heated chambers
- provides validation data for simulation
- provides surface shape information



Accuracy

The high quality hardware and high accuracy algorithms deliver class leading performance:

- displacement precision of 0.01pix (1/250,000 of the field of view) or better
- global strain precision of 10 micro strain or better
- local strain precision of 100 micro strain or better
- performance is equivalent to ASTM E83-10a and ISO 9513

Synchronized with the Test Machine

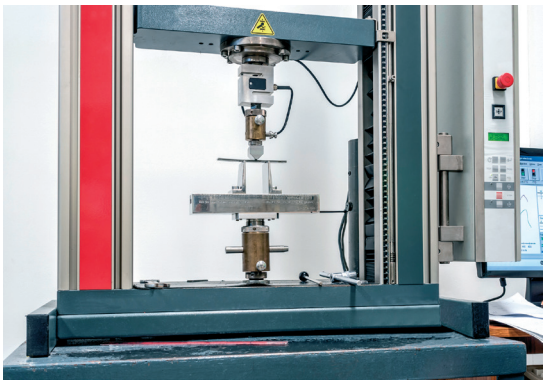
The **StrainMaster** system can be used in combination with any test machine – all that it requires is optical access to the specimen being tested. Custom mounts for test frames can be provided.

The **Device Control Unit (DCU) 11** fully synchronizes to your test machine:

- sequence start trigger
- individual data point trigger
- record analogue signals including load, cross-head displacement

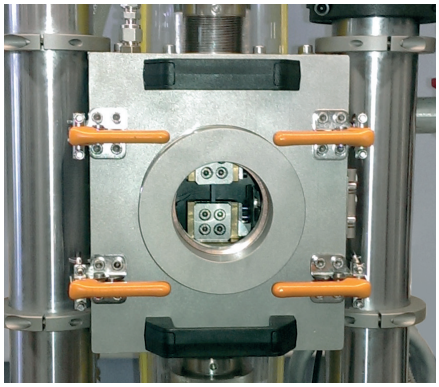
StrainMaster gives accurate full field results for all types of test including:

- compression
- flexure
- impact
- fatigue
- multi-axis
- cyclic
- tension
- thermomechanical



Environmental Chambers

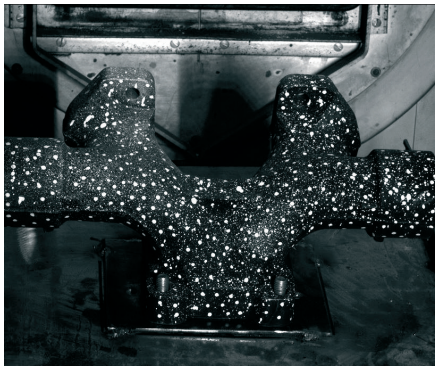
The system is extremely versatile and will work in challenging environments where traditional devices cannot function including:

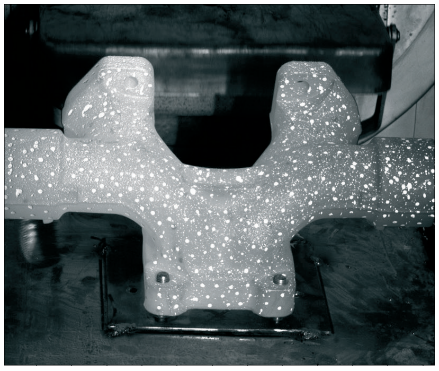


- samples submerged in liquids – our special calibration deals with strong optical distortions
- samples glowing at high temperature – optimized lighting and filters block the black body radiation
- shiny and reflective samples – specular reflection is avoided through the use of a patented polarizing filter technique (Patent EP 1739403B1)

High Temperature Testing

StrainMaster is applied to many different types of materials and components. It has the flexibility to be useful in many situations, even in challenging environments.





DIC measurements of a hot (800°C) exhaust manifold - with filter (left) and without filter (right) Acknowledgement: images taken during a project with KTH Royal Institute of Technology (Sweden) and Scania.

With high temperature paints to pattern the surface, and through special hardware add-ons we are able to see through the infra-red glow from the hot component. Displacement and strain maps can be calculated as the component is heated, and it is also possible to combine the DIC results with thermal maps from infra-red images because the IR camera can be mapped into the same space.

Plastics and Rubbers

Traditional mechanical gauges cannot cope well with very large strains, but **StrainMaster** can calculate data even where the displacements are very large and strains are >1000 %. This can often be the case where rubber or plastics are tested, and the example (right) shows a post-test thermoplastically formed sheet.

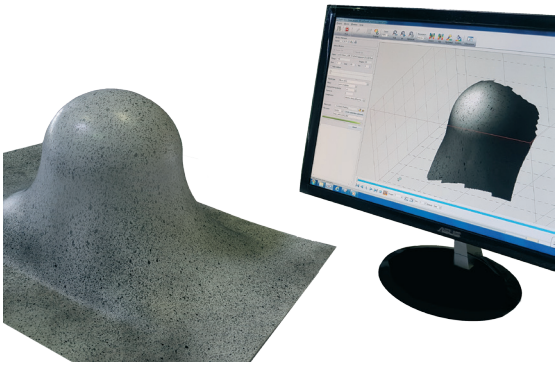
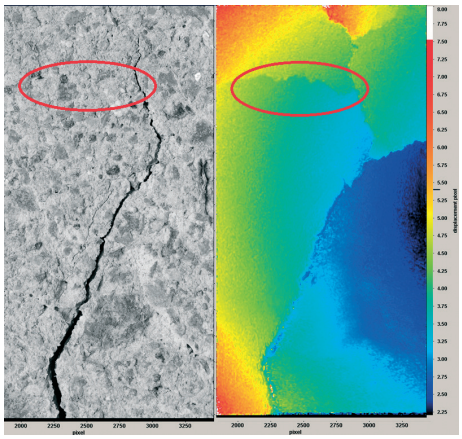


Image courtesy of Ecole Mines de Douai

Crack Initiation and Fracture

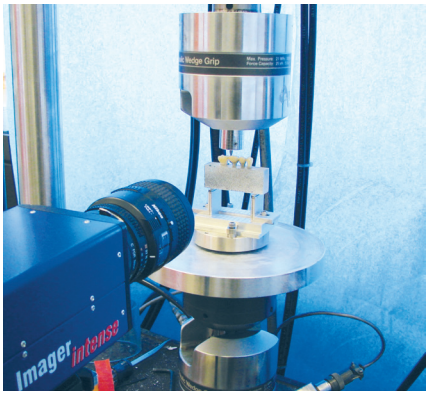


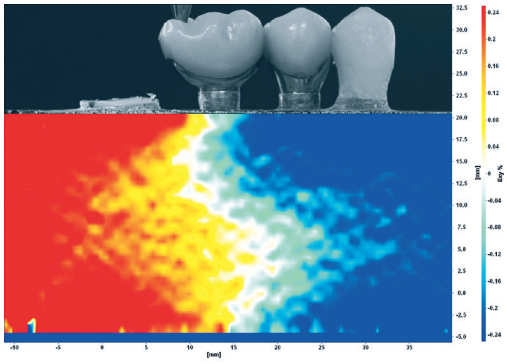
Because it is a full field technique and not restricted to obtaining data at the gauge location, **StrainMaster** can be used to identify strain hot spots, and subsequent crack initiation and propagation.

Cracks which are not visible by eye in the raw images can be revealed due to the sub-pixel accuracy of the DIC algorithm. The data can be used to calculate crack mode, crack opening displacement (COD), crack length, and crack path.

Biomechanics

Challenging environments are not restricted to high temperatures alone. It can refer to difficult optical access, or even samples contained in liquids such as saline solution for biomedical tissues.

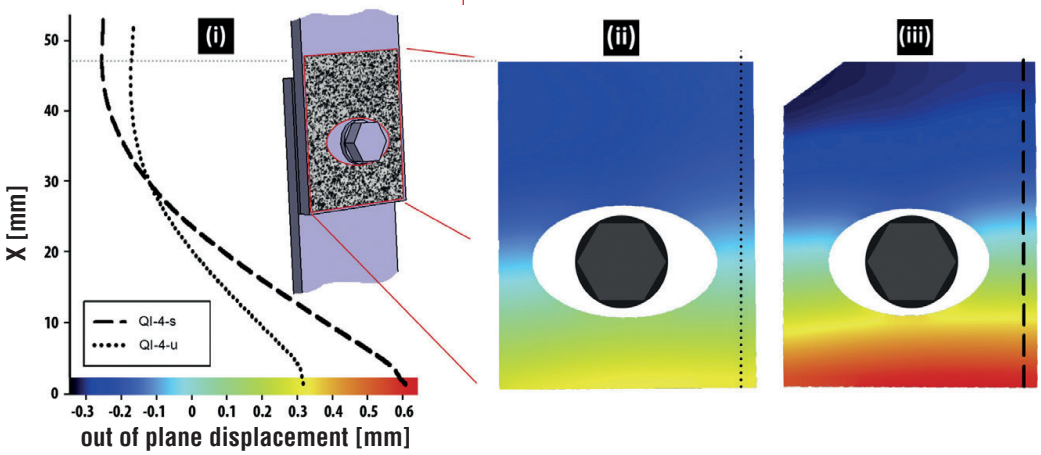




Analysis of implant-supported dental restorations (Courtesy of Dr Rodrigo Tiossi et al, Dental School of Ribeirao Preto, University of Sao Paulo, Brazil)

An area where it is difficult to use strain gauges, and where the understanding of the material characteristics remains challenging is biomechanics. The example here shows the deformation of false teeth during loading which simulates chewing. Other biomechanic type studies carried out with **StrainMaster** include studies of simulated aneurysms, shape memory alloys used in stents, and tensile testing of real bio-tissues.

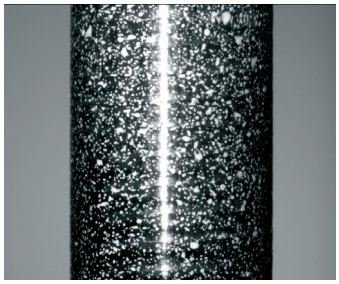
Composites

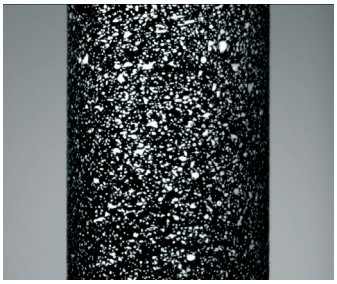


Composites represent another area where we are still trying to properly characterize the material for input into finite element models. **StrainMaster** has been used for various composite testing including pre-damaged panels, and compression after impact.
In the left example two composite panels connected via a bolted joint have been studied using a **StrainMaster** system. The out of plane deformation is shown here.

Metal Specimens and Components

A large proportion of **StrainMaster** applications include metal specimens or components being testing in tension, compression, bending, or torsion. With metal specimens (and other types of material) significant problems can occur due to specular reflection from the material surface. To avoid this, **StrainMaster** Portable systems are equipped with polarizing filters as standard. In the image you can see the dramatic reduction in reflected light through the use of polarization.

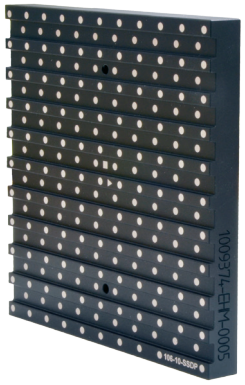




At the heart of the system the **DaVis** DIC software gives complete control and management over your data collection, processing, and reporting. The software is extremely intuitive with a logical data and menu structure.

Calibration

Like any device, the **StrainMaster** system must be calibrated for the test. This is not something that LaVision has to do though - there is no manufacturer system calibration required. You will be trained to calibrate the system; a process which typically takes less than 5 minutes when using our special calibration plates.



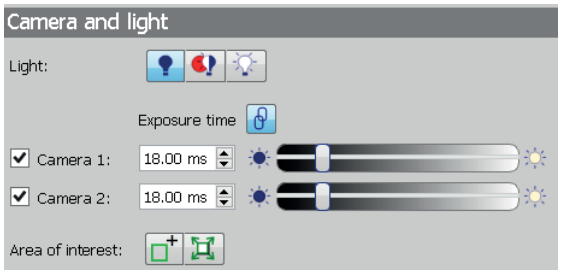
Having focussed on the sample in the test machine:

- you choose the calibration plate type in the drop down menu
- place the calibration plate in front of the sample
- the software automatically detects the calibration markers
- feedback is given on the calibration quality

The calibration process enables the system to map from the camera space to the real world space. The calibration plate can be inside a chamber or within a liquid.

Recording

Having calibrated the system you are now ready to configure the recording of images and analogue signals (load, displacement) from the test machine

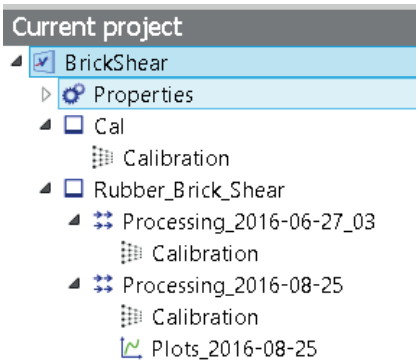


- multi-channel A/D recording
- ability to pause the test without corrupting data
- fast frame rates to capture dynamics
- continuous live view of the sample
- area of interest selection

Image sequences are automatically stored in the project.

Project

Throughout the whole process, all images and any calculated data or plots are stored within the project structure:

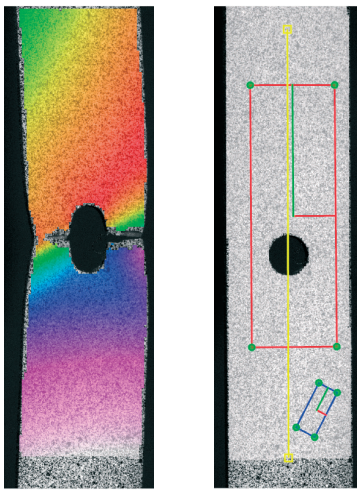


- user defined workspaces
- complete traceability
- organize by test, material, or specimen type
- logical tree structure for images and data
- calibration associated with each recording
- reactivate calculation parameters
- export data sets for support

Strain

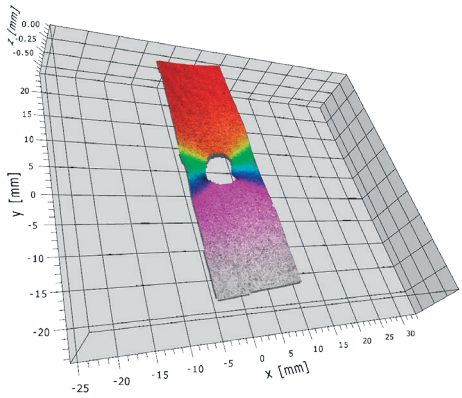
With the system calibrated and sequence of images collected during the test you are now able to perform the full field displacement and strain calculation.

- calculate data for the whole, or just part of the sequence
- select regions of interest or use AutoMask to automatically isolate the material surface from the background image
- test your processing scheme
- choose calculation modes which optimize displacement (and strain) precision or spatial resolution



Extras

As part of the calculation process you can choose different display and strain calculation modes depending upon the test and investigation type.



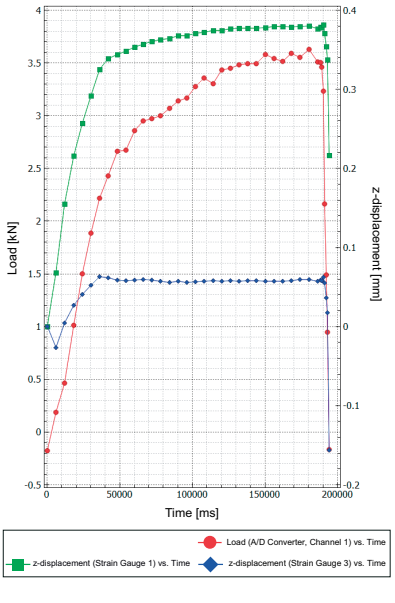
- 2D display with the raw image in the background
- 3D display to visualize surface shape
- colour coded surface maps of displacement component or strain
- choose the strain type (Engineering, Green-Lagrange, Hencky, etc)
- axial, transverse, shear, or principle strains
- Poisson's ratio

You now have a rich dataset of full field data covering the whole surface. You can use this to identify strain hot spots, or locate crack initiation and propagation, and export the data in image, text, or finite element formats.

Plot

You are also able to extract virtual gauge and extensometer plots to make comparisons. You don't need to know where to place the virtual gauge before you start the test!

- multiple gauges and extensometers
- strain calculated according to the local gauge orientation
- plot versus time
- plot versus recorded data (load, cross head displacement)
- export data for comparison



DaVis DIC software is easy to use and its simple workflow allows you to optimize your material test procedures.

StrainMaster Portable
System Components

Depending on the application LaVision's **StrainMaster** systems integrate different light sources and cameras:

Standard camera	Features
	excellent image quality, fast, CMOS cameras with up to 16 million pixel, USB 3.0 interface and frame rates up to 155 Hz*.
	unsurpassed high-resolution digital cameras, equipped with the new generation 8T global shutter CMOS sensor and a CoaxPress CXP6 4-lane interface for unbeaten transfer speed. Outstanding image quality with 25 million pixel/84 Hz or 48 million pixel/30 Hz.

* depending on system configuration

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