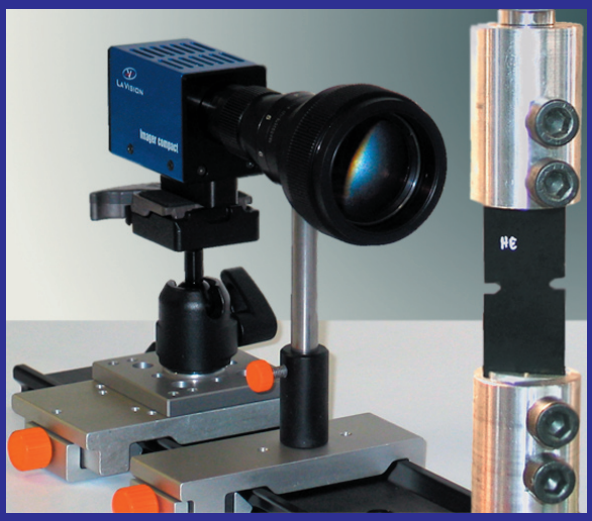
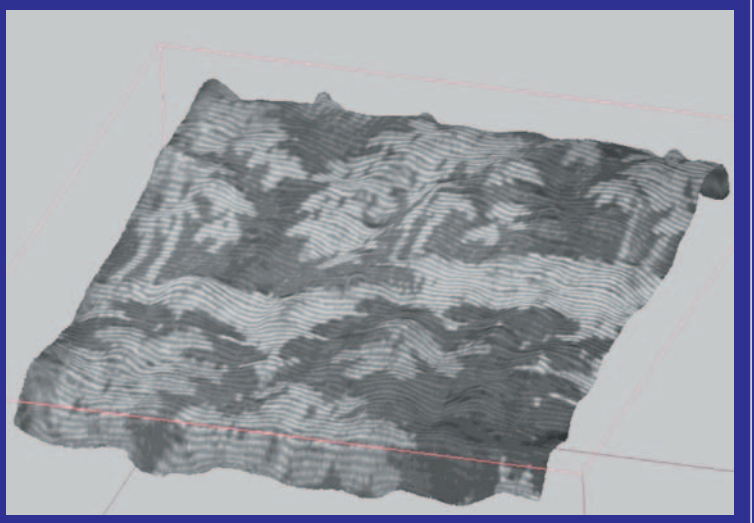
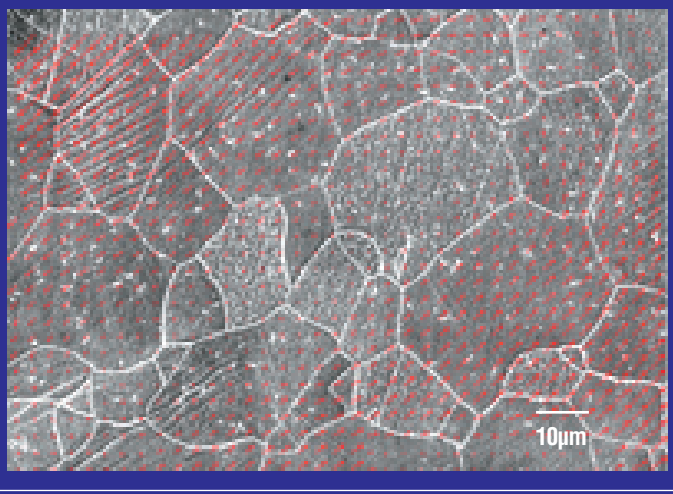
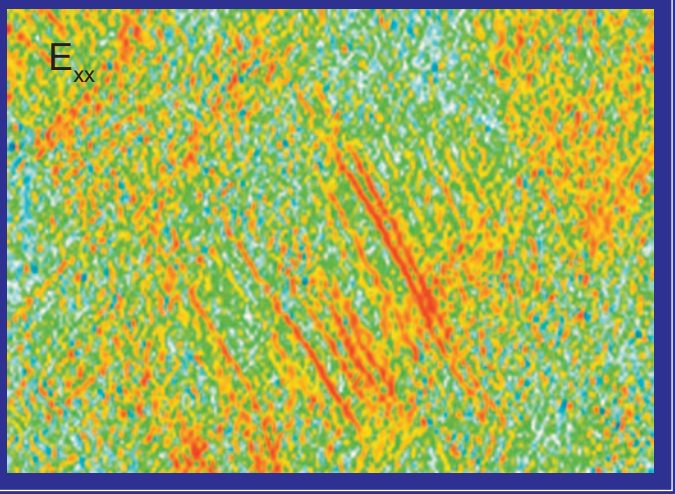








StrainMaster

Advanced Image based Tools for Optical Deformation and Strain Measurement

LaVision

We count on Photons

StrainMaster

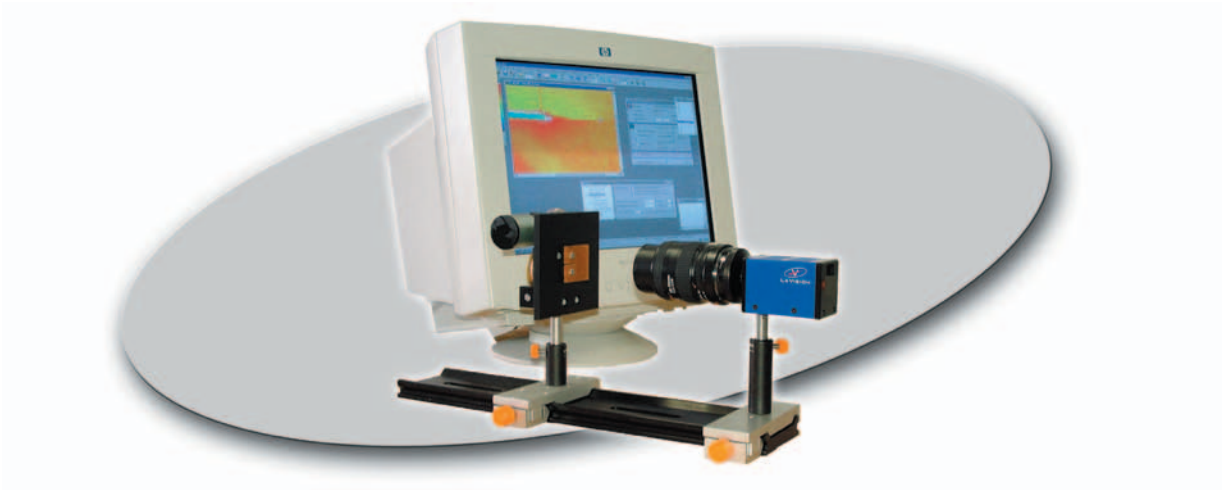
optical deformation and strain field imaging

StrainMaster from LaVision is a state-of-the-art, non-intrusive optical tool for shape, deformation and strain analysis of solid, granular and liquid subjects. **StrainMaster** combines the most advanced Digital Image Correlation (DIC) algorithms with the highest quality hardware to provide a complete and easy to use device for material analysis. **StrainMaster** is applicable across all industries investigating material behaviour and gives fast and highly accurate results via an easy to use PC based interface.

applications

- **solid components, granular movement or liquid flows**
- **Non-Destructive Testing (NDT)**
- **fracture mechanics**
- **Thermal Mechanical Fatigue (TMF) tests**
- **long term tests or ultra fast deformation analysis**
- **microscopic to large scale experiments**
- **Fluid Structure Interaction (FSI)**

StrainMaster 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). The system offers a complete solution and data management system able to drive hardware, acquire images, process data, validate and display or export information.



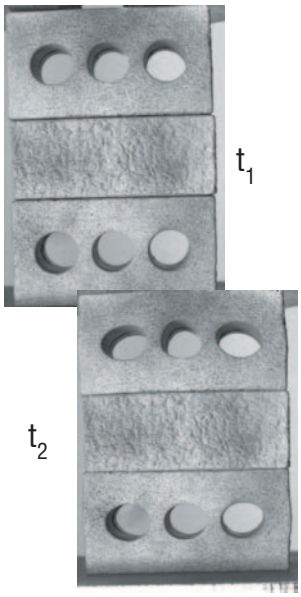
A range of **StrainMaster** systems are available from portable field work machines to highly specialized lab versions. Any system can be tailored to suit your particular requirements, and are appropriate for both industrial and academic applications across a range of subject areas.

industries

- **power generation**
- **biomedical / bioengineering**
- **polymer science**
- **mechanical engineering**
- **aerospace**
- **automotive**
- **geology and environmental**

StrainMaster

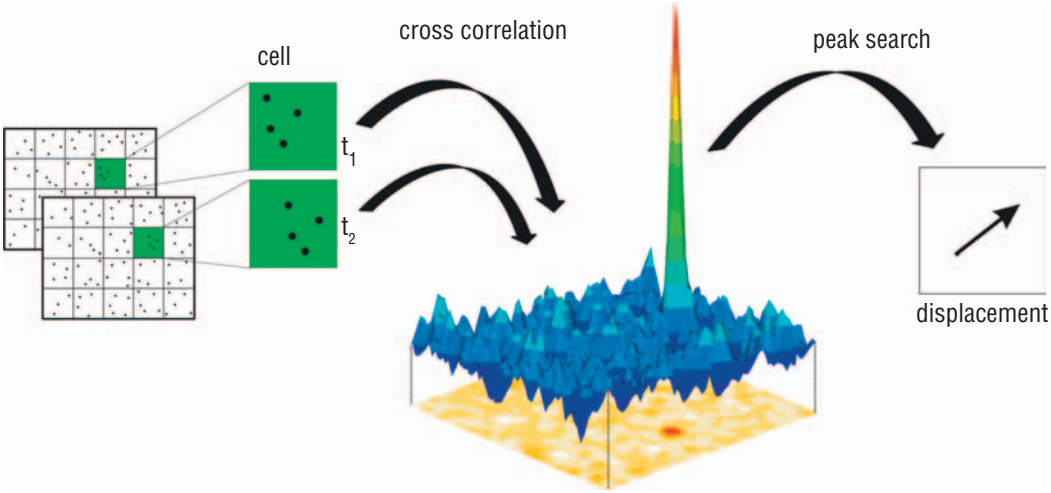
Digital Image Correlation



rubber bricks under compression

The system uses Digital Image Correlation with standard single camera or stereoscopic multi camera setups to record 2D in-plane deformation or 3D surface measurement. Our system uses highly accurate multi-pass Fast Fourier Transform algorithms to calculate the displacement of applied surface patterns or naturally occurring features.

The user typically acquires a series of images during a material testing experiment, with the first image normally being the case of zero applied load. The surface is illuminated by standard or specialized light sources and the displacement of the surface pattern between successive images is calculated by advanced grey scale analysis:



- Entire image of surface is discretized into smaller cells (interrogation cells).
- A correlation field is computed in each cell using Fast Fourier Transformation (FFT).
- The maximum correlation corresponds to the displacement.
- The displacement gives the vector length and direction for this window.

advanced algorithms

StrainMaster uses several advanced processing algorithms for maximum accuracy:

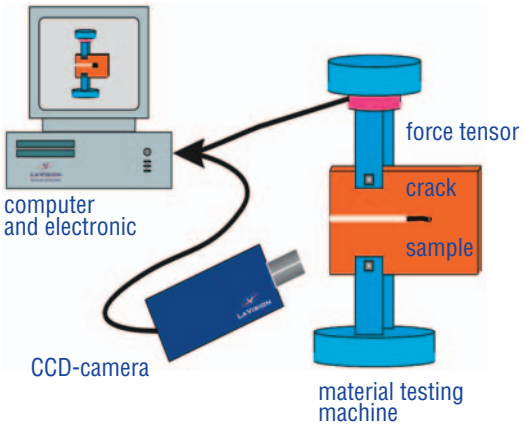
- multi-pass processing to maximize the retained particle pattern within each cell even for large displacements
- deformed interrogation cells to eliminate correlation peak smearing
- Whittaker reconstruction mode for unmatched sub-pixel accuracy
- choose cell size and shape (square or non-square interrogation cells)
- ability to measure from 0.01 to 1000 pixel deformation

accuracy

When utilizing larger cells, more information is available in the contained pattern and therefore the measured displacement is more precise. Accuracies down to 0.01 pixels are possible using larger cells, yielding local strain accuracies of 40µstrain or better. Global accuracy across images using the incorporated strain gauge feature can be down to 3µstrain with high resolution cameras.

StrainMaster

working principle



After the suitability of the natural or applied pattern has been assessed and any necessary illumination organized, the measurement and analysis can take place. Note that the viewed image is easily calibrated using simple geometry information known about the subject for 2D. The supplied two level calibration plate in conjunction with our highly accurate calibration algorithms can be used for 3D cases. The calibration procedure can take place before or after the data acquisition.

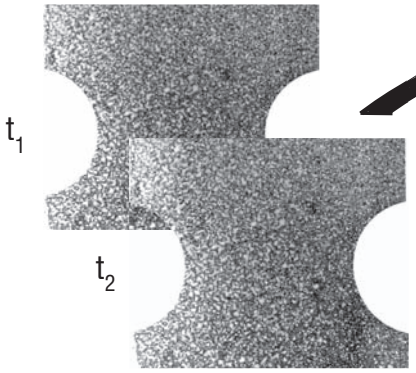
I. Image acquisition or import is controlled via the software. The image sequence is recorded and stored in a project, or alternatively images are easily imported.

II. The deformation is calculated using advanced cross correlation algorithms yielding a grid (matrix) of surface displacement vectors. Rigid body motion can be removed via shift and rotation correction.

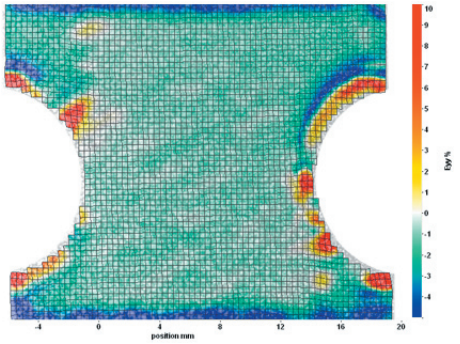
III. Validity of the displacement vectors is assessed using local and global information about the sample deformation. Additional post-processing or filtering is also possible.

IV. Displacement data is displayed in vector or grid form, and can show strain derivatives as background contours together with the original sample image in order to clearly identify maximum strain locations and fracture mode behaviour.

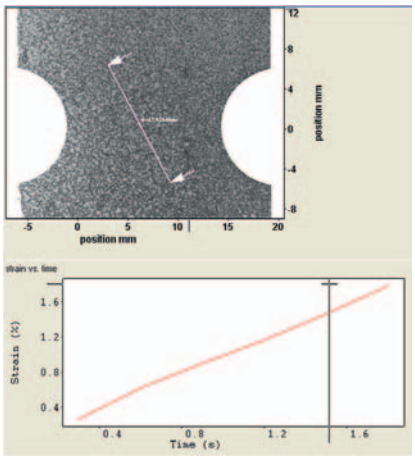
V. The incorporated virtual strain gauge feature allows the user to place a gauge anywhere on the sample after the test is complete. This can be plotted against time, or load data recorded using an integrated analogue to digital converter



composite structure tensile test



deformation grid and strain contours



strain gauge

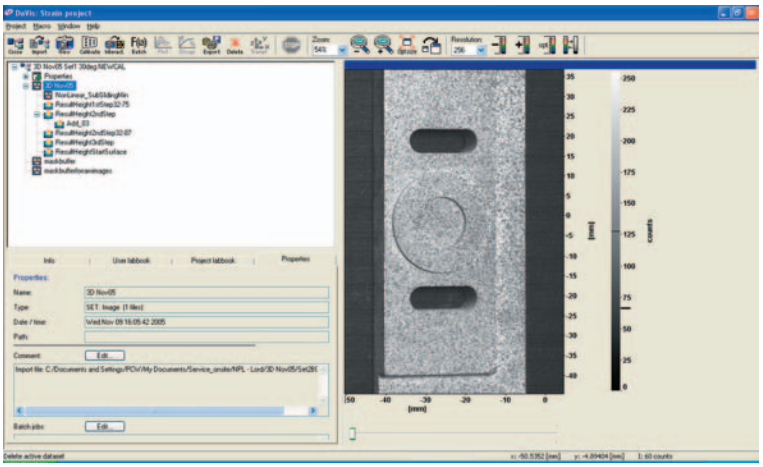
Tensile test on notched composite specimen - specimen provided by the University of Nottingham

StrainMaster

complete solutions

During image acquisition the powerful **StrainMaster** system is able to command pulsed lighting, automate translation stage movement, control camera exposure and frame rate, record analogue load data and synchronize with external (e.g. cyclic) events.

During post-test calculations, the user is able to set up batch operations for multiple processing steps, set up a hyperloop processing sequence to do calculations on multiple image sets, and even utilize the resources of networked PCs via a distributed processing system. All recorded images and resultant data are managed within the active **StrainMaster** project.



StrainMaster project

- easy set up and analysis
- fast data acquisition
- complete data management
- control and synchronization with external devices (phase locked measurements)
- maximize resource utilization via batch and distributed processing

software abilities

The **StrainMaster** software provides a complete data management system. A project is created for each test, and this contains the data tree of raw images, calculated data and derivatives. The batch operation mode for image and data calculation can include user defined functions written in the macro programming language, providing maximum flexibility. The data structure within the project is mirrored in windows explorer so the file management is completely transparent. Storage of images uses a special lossless image compression algorithm to minimize the required disk space, although export of standard formats is also simple.

special features

- moving mask to automatically adapt with shifting boundaries
- shift and rotation correction to remove rigid body motion
- virtual strain gauge (video extensometer) included as standard
- 3D display for overlay of image on recorded surface height
- variety of export file types including multiple window movies
- image stitching which can be automated with translation stages for very high resolution image generation
- vector or grid display combined with strain map and raw images

StrainMaster

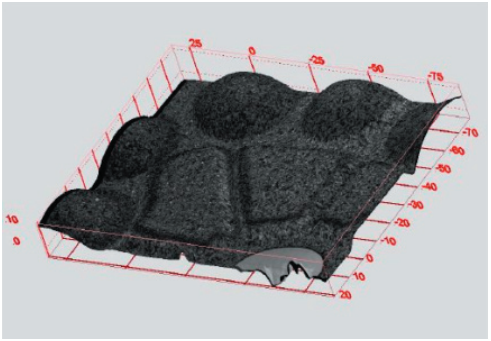
2D analysis

2D analysis is appropriate where surface height deformation is negligible. The right example shows a typical tensile test, with the image sequence indicating the increased strain levels in the sample. On the front cover the lower left image shows a sample of stainless steel under compression including the overlayed deformation field viewed by SEM. On the right image the corresponding strain field Exx is computed showing local shear bands.
Image courtesy : Dr. Joao Quinta da Fonseca MMSC, Manchester University

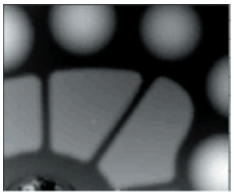
strain development within a stretched sample

3D analysis

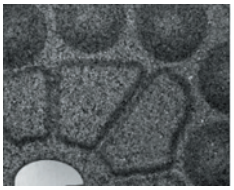
The calibration process for 3D measurements is made easy with the supplied two level calibration plates.



With a 3D (stereoscopic) setup, analysis of shape, deformation and surface strains is possible. The advanced display allows original images to be overlaid on the measured surface height. The example on the top right of the front cover shows the measured surface (amplified to illustrate changes) of a tapestry material.
Image courtesy : Dr. Janice Barton, Southampton University

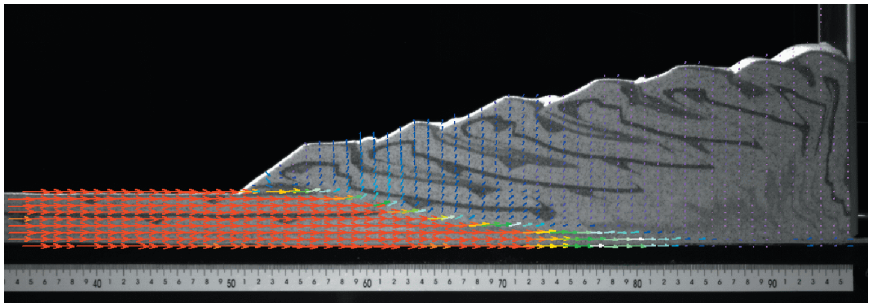


height



color

granular flows

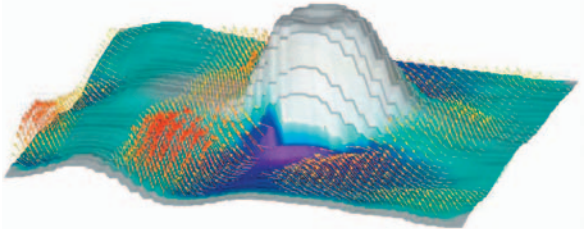


2D subsurface deformation (2D sectional view with displacement field)

The left image shows an experiment that simulates the deformation and mass transfer of tectonic plates. The simulation works with granular materials like quartz sand or micro glass. The **StrainMaster** system measures the motion of the different quartz sand layers and computes the strain field.
Image courtesy: Jo Lohrmann and Jürgen Adam, Geo Forschungszentrum Potsdam, Germany

surface flows

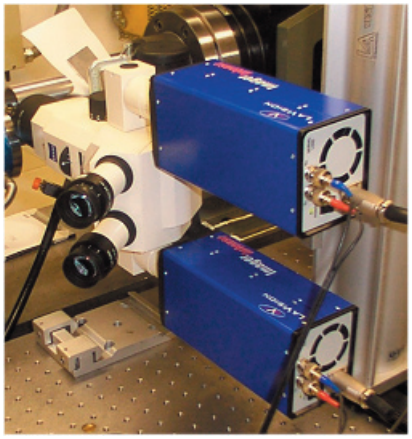
A useful upgrade to the **StrainMaster** system allows the analysis of free surface flows in terms of their shape, deformation, and velocity changes with time. The image below shows the visualization of water waves impacting on an obstacle. This new analysis tool is ideal for coupling the effects of surface shape with surrounding flow field.



StrainMaster

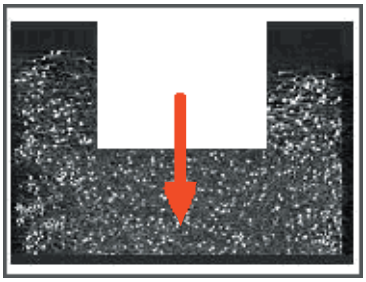
hardware upgrades

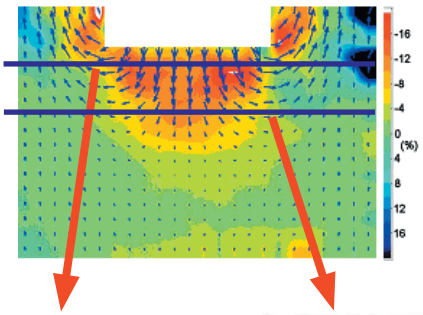
A variety of hardware upgrades and additions are possible to LaVision **StrainMaster** systems, to suit every customer's requirements. Multiple camera control with frame rates up to 1,000,000 fps and resolutions up to 11Mpix are possible.



- A/D converter for measuring simultaneous load cell data
- microscope setups for small scale investigations
- translation stages for automated data acquisition across a region
- PC Raid storage systems for high data volumes
- a variety of specialized lenses for the cameras
- Image Doubler for combining measurement techniques, e.g. PIV & Strain using one camera

software upgrades





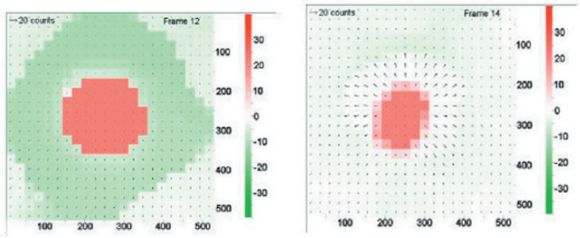


Image courtesy: Dr. Sam McDonald, University of Manchester

- **PointTracker**
  To evaluate position, movement and deformation of discrete points on a subject. Accurate measurement is achieved by tracking and recording distances between markers on the object.

- **Particle Image Velocimetry (for Fluid-Structure Interaction studies)**
  Using laser light sheet illumination to measure the fluid mechanics of a flow impinging on an object. This could be utilized to analyse the interaction of airflow on a wind turbine blade and to measure the resultant blade motion.

- **Optical Crack Tracer (OCT)**
  Working on a variety of materials, OCT measures and tracks a crack during initiation and propagation. It calculates the Critical Stress Intensity factor and Strain Energy Release rate. Optical Crack Tracer is a development of LaVision in coorporation with Fraunhofer Institute IZM.

- **Surface Flow, for free surface liquid applications**
  Studies free surface flows and their interaction with solid surfaces.

- **Tomographic software analysis package for full volume calculations of X-ray or CT scans**
  Analysis of full volume information of a material, yielding a 3D volume of 3 component deformation data.

StrainMaster

Specifications

	Standard	Optional
CCD resolution	1600 x 1200 pixel	up to 4000 x 2600 pixel
CCD dynamic	12 bit	up to 16 bit
CCD shutter gate	1 µs	down to 100 ns
repetition rate	30 frames/ s	up to 10^6 frames/ s
accuracy	down to 0,01 Pixel 40 µstrain locally 3 µstrain globally	
optics	f= 50 mm; 1: 1,8	micro zoom microscopes long distance microscopes telecentric lenses
electronics	A/D converter 12 bit dynamic 8 input channels 250 kHz sampling rate sync board	
computer	Dual Core MS-Windows	
LaVision Software	DaVis 2D / 3D Strain	Crack Growth Analysis Crack Statistics K1c and G1c Package

StrainMaster components

- computer
- software
- CCD camera
- electronics
- A/D converter for external signals
- sync board

options:

- illumination sources
- 3D upgrade
- wide range of LaVision's CCD cameras
- optics, microscopes
- mechanical setup
- image stitching (automatic image stitching, using translation stages is optional)
- motorized stages

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