By correlating the intensity profile across successive images of an evenly lit strained surface, it is possible to infer in-plane surface displacements without the need for paints or grid markers. Scanning electron microscope, optical microscope and video images can be used.

**FACILITIES**

**Image Acquisition:**
Microscale – Modified Jeol SEM.  
Mesoscale – Zeiss optical microscope with motorised stage and high-resolution 12-bit camera.  
Macroscale - A variety of sources, from 8 bit 500 x 500 pixel to 12 bit 1300 x 1000 pixel digital cameras to video cameras.

**Software Packages:**
LaVision PIV (particle image velocimetry).  
Bayesian Probability Algorithm, developed with Prof. WC Clocksin, Oxford Brookes University.  
Displacement maps can be generated to sub-pixel accuracy, and strains determined to 0.1% accuracy.

**Case Study (1) Plastic deformation in coarse and fine-grained materials at a microscopical level.**

![Strain map](image1)

Strain map between first and final (shown) images of the sequence obtained during in-situ testing of a large grained ferritic steel.

![One of a sequence of SEM images used to map the surface strain in fine-grained ferritic steel, together with the corresponding strain map.](image2)

One of a sequence of SEM images used to map the surface strain in fine-grained ferritic steel, together with the corresponding strain map. Despite the noise inherent in SEM images, transgranular shear bands can be clearly identified. The algorithms used are applicable to any image, at any scale from the microstructures in this example to the macrostructures of the next example.

**Case Study (2) Compression induced strain in a steel environmental crack growth specimen.**

![Displacement map](image3)

Displacement map (left) deduced from initial (shown) and final images of compressing a compact tension specimen. In contrast with the previous example, the field of view here is 20 cm. The local strain varies from highly compressive at the notch to highly tensile near the back face. Top right is the inferred axial residual strain map, bottom right is the prediction of a plane stress finite element model. Thousands of strain gauges would need to be used to achieve an equivalent strain map.

**Case Study (3) Thermal Barrier Coatings.**

Image correlation can aid the characterisation of deformation and failure mechanisms in coatings. For many systems, surface measurements do not reflect bulk behaviour, but for coatings surface strain is precisely what is required. As no pattern needs to be applied to the surface, debonding and other failure mechanisms can be directly related to the surface cracks, blisters and inclusions.
**CASE STUDY (4) NATURAL MATERIALS: TOUGHENING MECHANISMS IN ANTLER BONE.**

The microstructure of Fallow deer antler bone, prior to loading, with growth direction vertical and loading horizontal (top left image). Microcracks occur on loading - see regions of high strain in the map - relating to local microstructures. Also shown are stress/strain curves for the longitudinal and transverse directions, also obtained from image correlation.

**CASE STUDY (5) FUNDAMENTAL PLASTICITY STUDIES: TENSILE STRAINING OF A MAGNESIUM BI-CRYSTAL.**

A Mg bi-crystal, machined from a large cast ingot. The sample had through thickness grains, so crystal orientation and related slip planes and directions do not change below the surface. Whilst the lower grain in the images deformed solely by shear, the upper grain exhibited mainly twinning. These results can be used to test and refine finite element plasticity models that include texture evolution and its associated effects.