Electronic Speckle Pattern Interferometry

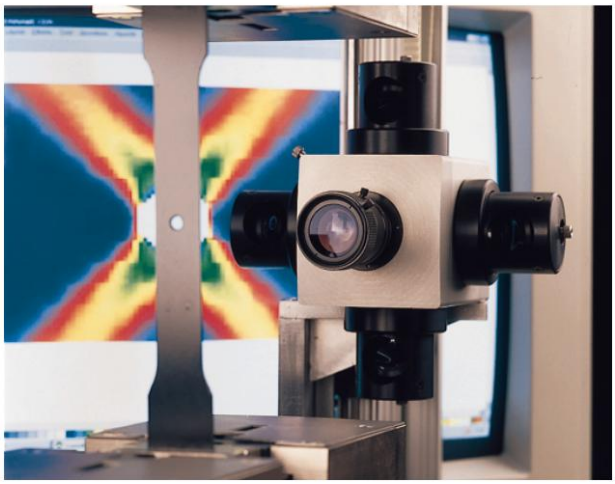
MANCHESTER 1824
The University of Manchester

STRESS & DAMAGE CHARACTERISATION UNIT

ESPI is an optical technique allowing full field measurement of surface displacement. This method utilises surface-generated laser speckle to map variations of displacement without requiring any marking or contact with the surface.

EQUIPMENT

The Unit has the Q-300 3D ESPI system controlled by the Istra software package, both produced by Dantec Ettemeyer. The ESPI system is suspended so as to move at half the crosshead speed to minimise rigid body displacements.

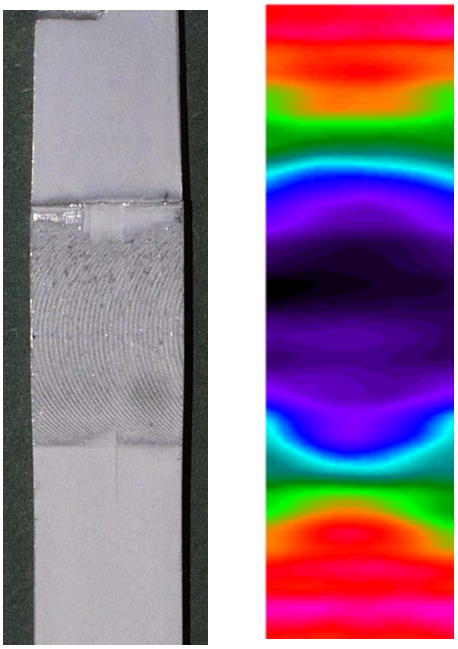


Several macro lenses can be used to provide the field of view from 3 x 3mm to 100 x 100mm. The displacement and strain resolution of 5 mm/pixel and the measuring accuracy of 0.03mm can be achieved for both in- and out-of-plane measurements at high magnification due to a phase shifting technique.
The ESPI is thus particularly well suited for cases where high strain gradients are present, such as micro and macro heterogeneities, cracks or welds.

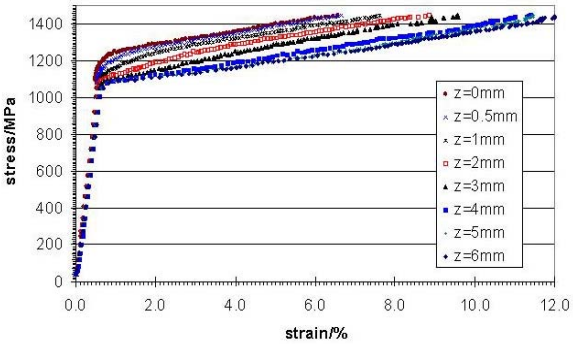
CASE STUDY (1). MECHANICAL PROPERTIES OF A FRICTION STIR WELDED ALUMINIUM ALLOY.

A hardness profile is an easy way to characterise material properties across the weld. Because of its simplicity this approach is particularly popular in industry. The ESPI offers a high-resolution full field alternative to the hardness test.
A welded sample was subjected to tensile load across the weld line. The resulting strain field shows the weld to be stiffer than the parent material. Low strain areas are shown in black and high strain regions are shown in pink.

Welded specimen. Vertical strain.

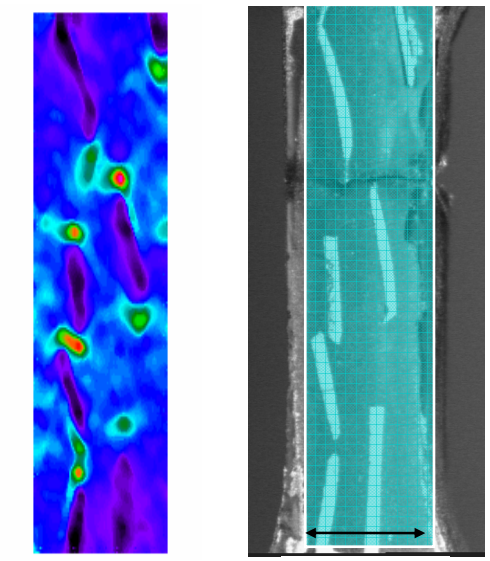


Stress-strain curves across the weld show that hardening increases with proximity to the weld line. Z is the distance from the weld.



Case Study (2). Localised strain in mild steel reinforced polymer.

Analysis of cases involving highly localised strain require a high spatial resolution measuring technique. If strain changes significantly over distances of about 1-2 mm then
strain gauges cannot normally be used. ESPI shows the whole strain field with high strain localised in matrix at ends of reinforcements.

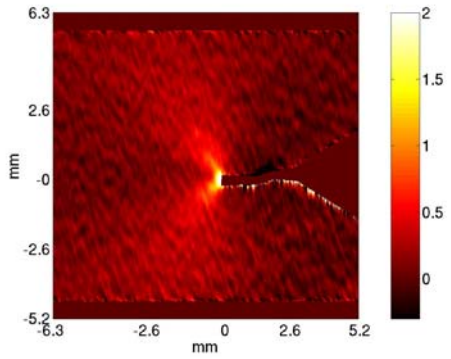


5mm

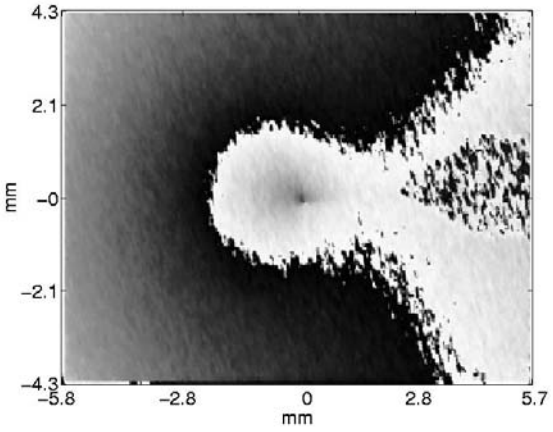
Case Study (3). Crack tip strain field in Aluminium alloy sample.

Displacements in cracked bodies are hard to measure experimentally due to very high strain gradient close to the crack tip and because of displacement discontinuity across crack flanks for opening mode or along crack flanks for in-plane shear mode.

This ESPI vertical strain map shows a classical "butterfly" pattern. Note that the crack itself is masked to avoid errors during the phase unwrapping stage.

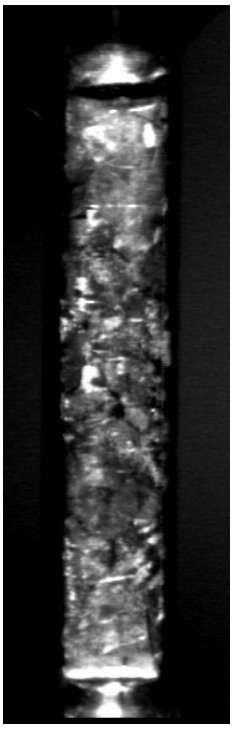


Precise location of the crack tip usually is hard to establish experimentally. The ESPI out-of-plane wrapped phase map shows the crack tip position with 0.1 mm accuracy.

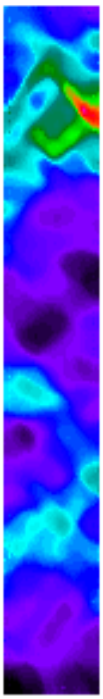


Case Study (4). Strain measurement in large grain material.

Significant variation in strain might exist in large-grained Ti-6242 alloy during a tensile test. The application of tens of strain gauges at different locations will be needed to study such variation. As ESPI produces strain at every pixel it is much superior to the conventional strain gauge method.



Sample



Vertical strain

For more information on Electronic Speckle Pattern Interferometry contact:
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