Laboratory X-ray Diffraction

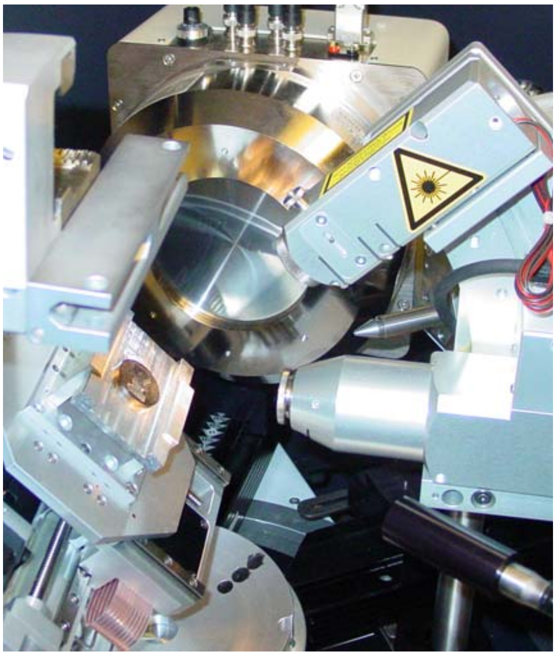
The University of Manchester

STRESS & DAMAGE CHARACTERISATION UNIT

Diffraction can measure the lattice spacing of crystalline materials very accurately. The spacing changes slightly when the material is under stress and can be used as a 'strain gauge'. Laboratory X-rays penetrate only a few tens of microns into the sample, consequently the stress normal to the surface can usually be assumed to be zero and a technique known as the bi-axial $\sin^2 y$ method can be applied; a strain free calibration sample is not required. Residual stress is calculated using Hooke's Law. In more complex cases, where a stress component exists normal to the surface, a tri-axial approach can be employed. Set-ups for rapid texture evaluation and small angle scattering experiments are also feasible.

FACILITY

A 'state of the art' GADD system from Bruker AXS, equipped with Eulerian cradle from Huber, area detector and laser/video sample alignment. Most metals and samples of varied shape can be analysed.

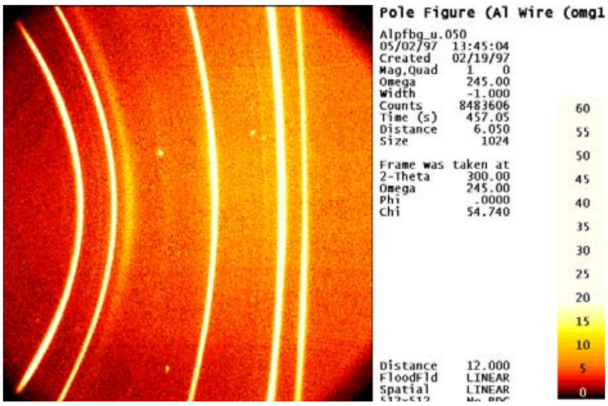


Contrary to using conventional diffractometers, samples need not be flat. Target areas as small as 50mm across can be analysed. The area detector can collect a large section of the Debye rings, as shown in case study (1). Micro-diffraction of phases and inclusions down to a few microns across is also possible.
This wide-angle scattering system is transformable into small angle scattering one that covers the size range between 10Å and 1000Å, allowing determination of the size, shape and distribution of particles in suitable materials.

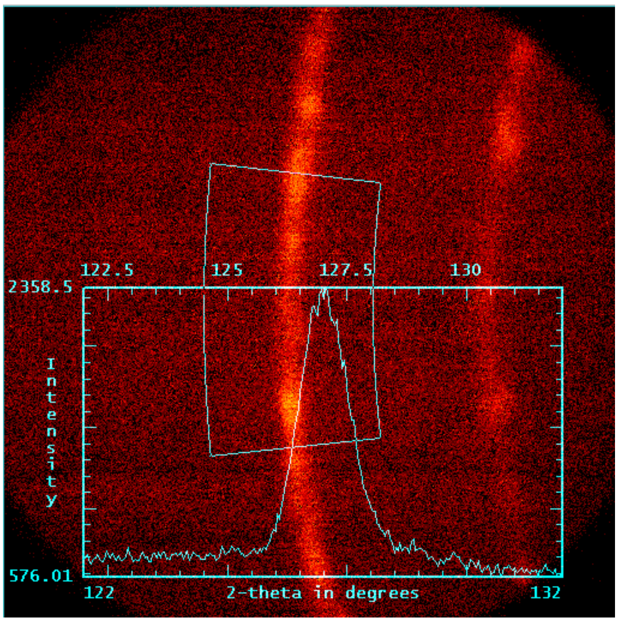
SUITABLE SAMPLES

Up to 25 ´ 25cm, with a thickness of up to 30 mm.
Maximum weight: 10 kg.
Maximum weight of smaller samples for residual stress/ strain mapping: 5kg
Range for strain mapping, ± 70 mm for x and y.

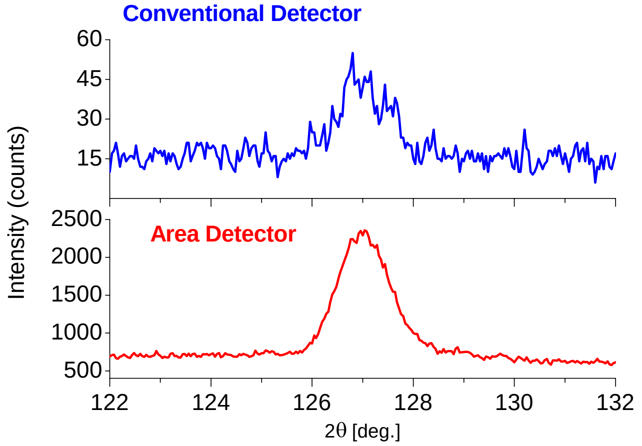
CASE STUDY 1 - ANALYSIS OF ALUMINIUM WIRE.



The area detector enables rapid data collection as the intensity can be integrated around the Debye rings. Samples which show strong, preferential orientation can be analysed more easily as the uneven intensity can be integrated around the rings. The effects of large grain size can also be minimised by oscillation in x or y.



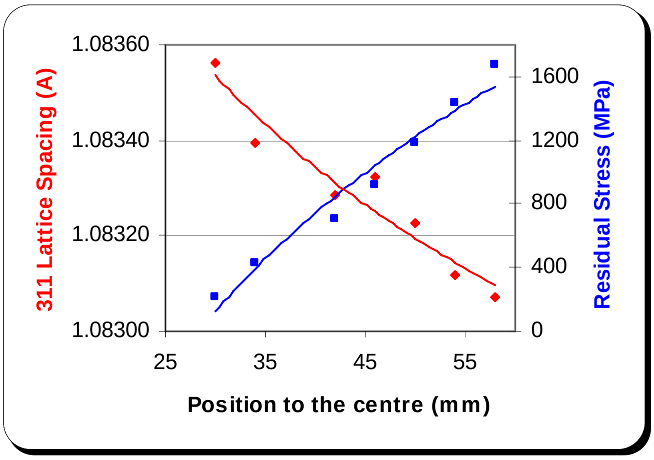
The (311) reflection measured from the same point on a Ni-based specimen with both conventional point detector and area detector can be compared in these plots:



weld. The set of measurements using six 'y' angles at twelve locations took less than an hour to complete.

CASE STUDY 2—MACHINED SURFACE OF A NICKEL-BASED SUPERALLOY

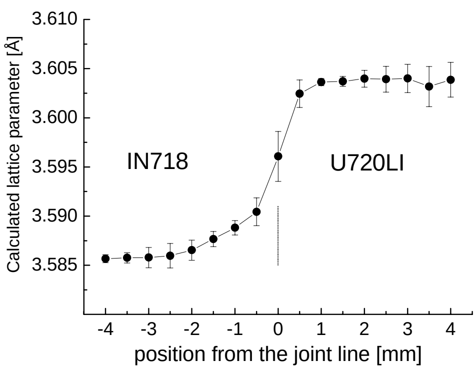
At the machined surface of a nickel-based superalloy, high tensile stress can found to increase from the inner to the outer radial position, which can be associated to the variation of unstressed lattice spacing as plotted. It shows that the 311



lattice spacing has a trend of decreasing from the inner radius to the outer radius, indicating the evolved thermal effect over the measured range.

CASE STUDY 3 – STRESS-FREE LATTICE PARAMETER (A0) VARIATION ACROSS INERTIA FRICTION WELD.

Stress-free lattice parameter could be determined for a course-grained material such as in an IN718-U720LI weld using the Hauk's method. A huge number of measurements at different y angles could be routinely made over many days and nights by running script files, which are a very powerful feature of the GADDS software. An example of a0 variation obtained from



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