ESRF	**Experiment title:** Plastic Strain Determination Using Synchrotron Radiation	**Experiment number**: HS-625
Beamline: BM 16	**Date of experiment**: from: 29/1/99 to: 1/2/99	**Date of report**: 17/4/00
Shifts: 8	**Local contact(s)**: A.Fitch	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

G. M. Swallowe* , M. Butterfield*

Physics Dept. Loughborough University, Loughborough, Leicestershire, LE11 3TU, UK.

R.C.Wimpory *

Mechanical Engineering Dept. Imperial College, London, SW7 2BX, UK.

Introduction: Neutron strain scanning is now a well established technique at neutron sources. The Bragg peak positions can be used to determine residual strains within the body of an engineering component and hence provide valuable information on factors such as fatigue life. Analysis of peak shape changes is capable of providing information related to dislocation density and crystallite size and hence can, in principle, be used to map plastic deformation as a function of position within a sample. X-rays are normally limited to surface studies only but the very high intensities available at synchrotron sources enables sub-surface studies to be carried out. The aim of this experiment was to check consistency of results between neutron and synchrotron studies of plastically deformed metal samples.

Experimental: Experiments were carried out on 99.9 % copper, 99.0 % nickel and 99.5% iron samples. All samples had been prestrained to known plastic strains before their diffraction spectra were obtained. The iron and nickel samples consisted of 0.3 mm thick foils cut in the shape of standard tensile test specimens. The gauge lengths were approximately 20 mm and the width of the gauge length 5 mm. The copper samples consisted of 8 mm diameter cylindrical rods whose central area was machined down to 4 mm diameter with a gauge length of 20 mm. The copper samples had previously been used at an experiment on the ISIS and ILL neutron sources and were used to provide comparative data. All samples were initially annealed at 0.5 T_m in vacuum for 3 hours before being strained in a Hounsfield Tensile test machine. In each case slits were used to obtain diffraction patterns from an area 5mm long x 1 mm wide over the central area of the sample gauge volume. The samples were positioned so that planes oriented perpendicular (Axial) to the direction of the

applied tensile strain produced most diffraction patterns. Some samples were also oriented so that patterns were produced from planes parallel to the direction of strain (Transverse) so that a comparison of the peak broadening in both these directions could be obtained. The data was analysed on a peak by peak basis using the de Keijser method with the unstrained sample peaks acting as the deconvolution reference peaks.

Results : Figure 1 shows the crystallite cell sizes derived from the Lorentzian component of the peaks width in both the axial and transverse directions as a function of plastic strain for the Iron samples. It can be seen that the axial and transverse data agree within error. This is important since in many engineering processes the exact direction of plastic deformation within a component will not be known and if a measurement of peak width is to be used to estimate plastic strain it should produce the same result whatever the direction of the diffraction planes relative to the direction of strain. At neutron sources the response of the (200) reflection was observed to asymmetrical. It was thought that this assymetry could in principle be used as a marker of the direction of plastic deformation but the assymetry was not observed in the synchrotron data..

Figure 2 shows a comparison of the cell sizes as a function of plastic strain for the copper rods. Good agreement for the trend of size reduction with strain exists between the neutron and X-ray data. The vertical shift is due to the error in determination of the reference peak. The graph can however be calibrated by the observing the true grain sizes on test specimens.

Conclusion

The results of this experiment show that peak shape analysis of synchrotron radiation data produces coherently diffracting volume sizes which agree well with those derived from neutron data. This provides confidence in the consistency of measurements of a single sample with synchrotron data used for the near surface and neutrons to probe in depth.

Figure 1 Evolution of cell size in Iron foils

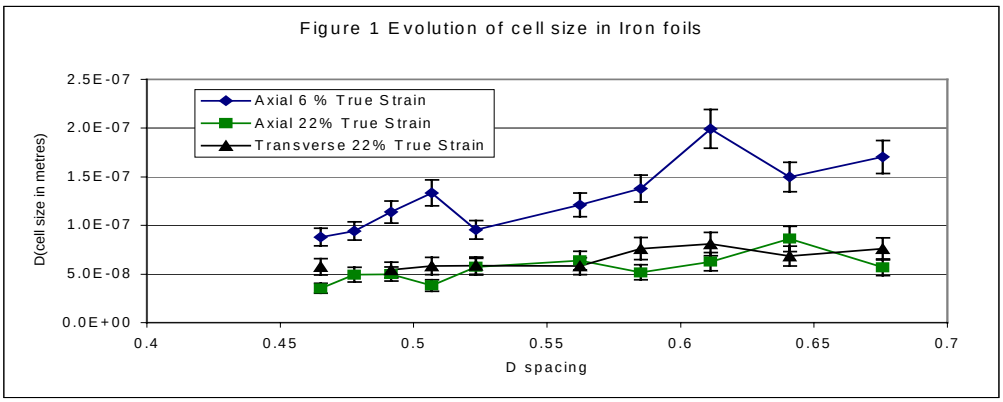

Figure 2 Evolution of Cell size with True Strain in Copper rods