ESRF	**Experiment title:** Residual stresses at scribe marks in aluminium alloys	**Experiment number**: MA447
Beamline: ID31	**Date of experiment**: from: 14/2/2008 to: 17/2/2008	**Date of report**: 25/7/08
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Report:

The initiation and growth of fatigue cracks in metallic materials is now well-understood. Fatigue cracks can initiate at stress concentrating features within a structure, but can also develop at smooth surfaces by localized slip on preferentially-oriented grains during cyclic loading.

Residual stress can also be critical in determining the rate at which fatigue cracks initiate and grow. Compressive residual stresses can extend the fatigue life of components, whilst tensile stresses are detrimental.

An area of fatigue assessment that it is poorly-understood, however, is how cracks are initiated at areas of fairly minor damage. Examples are scratches and dents which can occur during manufacturing or operation, and which may act as fatigue initiators. However, at present an exact assessment of the likelihood of a particular scratch to initiate a fatigue crack cannot be made. And indeed, scratches can sometimes initiate a fatigue crack, which then grows a small fraction of a millimetre and then arrests: an effect which is almost certainly a result of the local residual stress field around the initiation point. Work in the project to-date has indicated that scratches less than 100 microns in depth may not be deleterious, for example.

In this experiment we used ID31 to measure the strain fields around scratches in two different aluminium alloys. The aluminium alloys used were: 5091, a fine-grained (0.5 μm) alloy which is ideal for the measurement of stress fields that vary around fine-scale features such as scratches; and 2024, a widely-used alloy in aerospace, which is of broad industrial interest but whose relatively large grain size (30+ μm) makes fine-scale strain measurements more problematic.

Because measurements were made close to the sample surface, and near the edge of the scratch, it was necessary to use an instrument with an analyser crystal, to prevent the effects of spurious peak shifts arising from a partially-filled gauge volume.

The results are shown below for two different tool geometries. Both show peak tensile strains below the scribe tip, although curiously the higher strain values are seen for the tool which gives the highest fatigue life.

It may be that the tool also introduces considerable hardening to the material below the scratch tip, and this is being investigated further using nanoindentation methods.

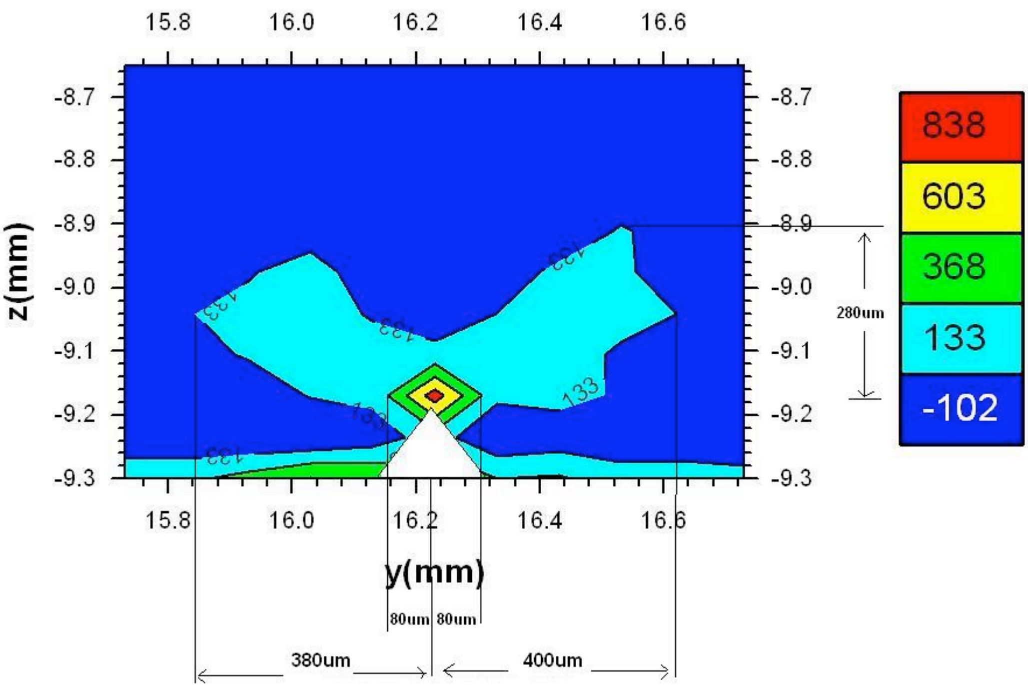

Figure 1: Transverse strain distribution map for the tool which gives the lower fatigue life

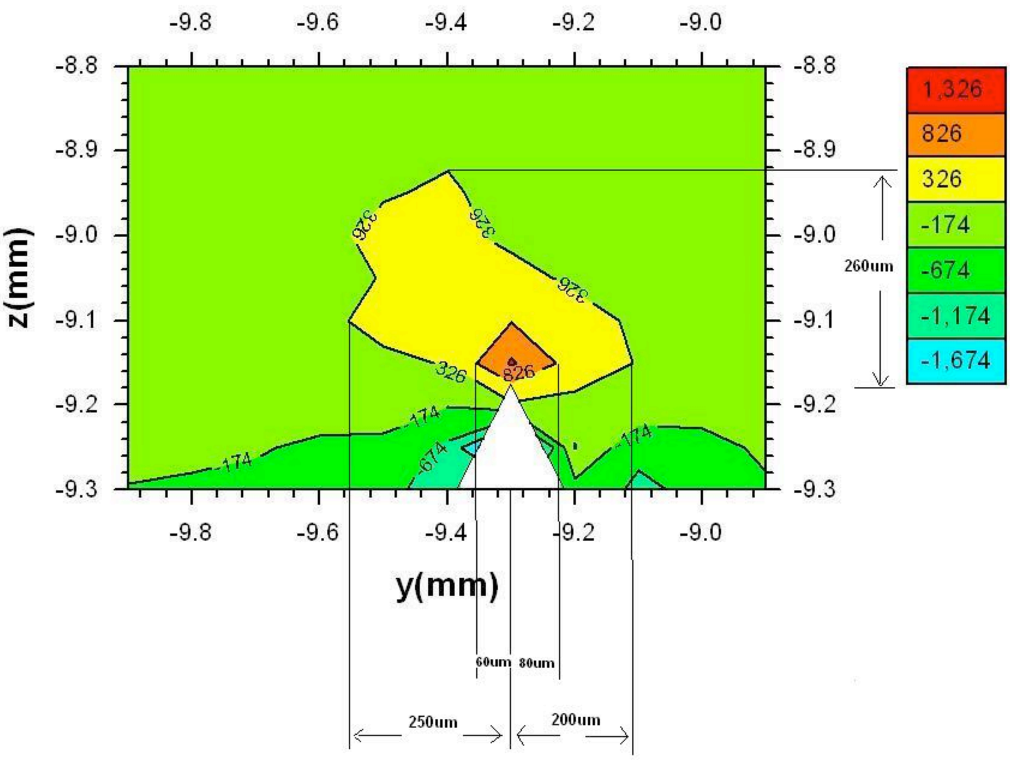

Figure 2: Transverse strain distribution map for the tool which gives the higher fatigue life

Future work will focus on the damage mechanisms associated with the generation of the scratch, and mechanisms by which pre-existing damage can be alleviated and the onset of cracking retarded.