	Experiment title: Stran scanning individual fibres in a multiple ply Ti/SiC compoisite	**Experiment number**: ME540
Beamline: ID11	**Date of experiment**: from: 17 May 2003 to: 22 May 2003	**Date of report**:
Shifts: 15	**Local contact(s)**: Dr Gavin Vaughan	*Received at ESRF:*

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Report:

The aim of the experiment was to measure strain in individual fibres in a composite specimen. This was achieved successfully for the first time in an MMC using the unique combination of capabilities available at ID11: the new refractive lenses at hutch 1 of ID11 provided very fine focus; the receiving slits on the Kuma detector enabled a small part of the diffracted beam to be selected; the ability to tune the energy of the beam gave the required gauge volume. The experiment built on data already obtained during ME363, in which strain distributions were measured as an average through the thickness of each ply. One of the same specimens used in ME363 was measured again in ME540. Since the Kuma detector required long exposure times (up to 5 minutes per point), it was impossible to map the strain in every fibre during the experiment. Therefore two of the same load levels were used, and selected fibres were mapped along half their length. The data obtained was in good agreement with the previous data, but was obtained from individual fibres rather than being an average of a ply. This difference is essential to the quality of the information that can be obtained about interface behaviour. The data from ME363 is shown alongside data from ME540 to build up a full picture of the composite strain patterns. Tomography performed at ID19 of the specimen (by Jean-Yves Buffière and Eric Maire during an extra session) is also shown with the data.

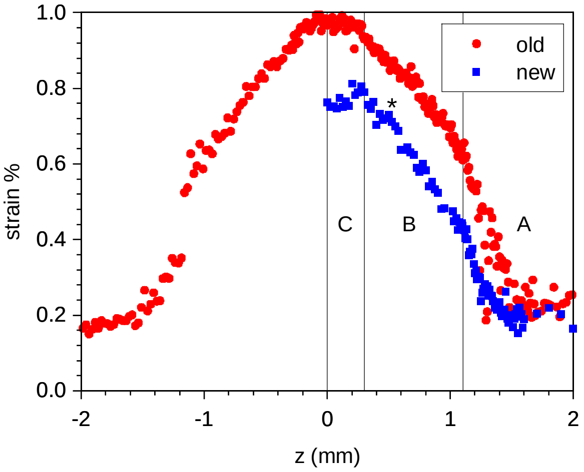

Figure 1. Data from ME363 (old) and ME540 (new) showing ply 1 at 1400 MPa load.

Figure 1 compares a strain distribution obtained from ply 1 of the specimen during ME363 (an average of the 2 intact fibres in the ply, obtained after deconvoluting the data into broken and intact contributions) with a strain scan of one of these fibres from ME540. The new data is less prone to ‘rounded off’ transitions between regions of different interface behaviour. There are 3 regions in the strain profiles. In the far field region (A) there is a curved build up of strain consistent with a fully bonded interface. At intermediate distance from the matrix crack (B) there is a linear build up of strain consistent with a frictional (debonded) interface. Close to the matrix crack (C) there is a linear drop in strain with the gradient approximately equal but opposite in sign to region B. This is known as 'reverse sliding' and occurred because the load relaxed during the experiment. There is also a 'sticking point' marked * on Figure 1 which is a small region where part of the interface retained a segment of reverse sliding from previous loading/ unloading cycles. The old data has rounded off transitions between the regions, due to the fact it was measured as an average of 2 fibres which had different z positions for the regions. The new data reaches a lower maximum than the old data. This is because the fibre was next to one broken fibre, but the other intact fibre in ply 1 was next to 3 broken fibres, so had to carry more load. The other fibre in fact had to be at a still higher strain to have created the average.

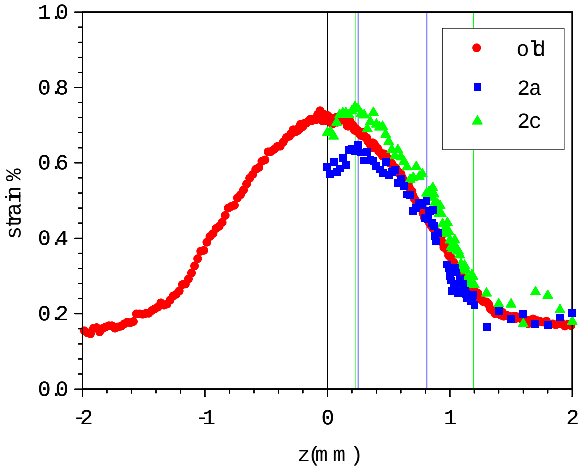

Figure 2 Data from ME363 (old) and ME540 (2a and 2b) showing ply 2 at 1400 MPa load

Figure 2 compares the strain data for ply 2 from ME363 and ME540. Fibre 2a is directly behind the intact fibres in ply 1 whereas fibre 2c is behind one of the broken fibres. It therefore reaches a higher strain. The regions and some sticking points have been marked for the 2 fibres. The extent of debonding in z differs in the 2 fibres by about 0.2 mm. This would contribute to the rounded off appearance of the old data.

The quality of the new data is strong evidence that the new data was indeed measured in individual fires, with no or hardly any overlap of the gauge volume into other fibres. We found during the experiment, using diffraction intensity scans in the long dimension of the gauge volume, that the gauge volume was just short enough to fit. Any overlap into the next fibre would have produced negligible diffraction intensity because the gauge volume is diamond-shaped and only the thinnest parts of the diamond would overlap.

Figure 3 shows a visualization (using software developed at Manchester Materials Science Centre) of the fibre strain data inserted into a tomograph of the specimen. The full-length 'fibres' are the old data and the half length ones are the new data. They are coloured according to the measured level of strain in the loaded condition.

The data were also used to calculate interfacial shear stress distributions along the fibre length, which are not shown. These data are highly valuable because they yield information about the strength of the interface and the damage occurring due to fatigue.

We have achieved the aim of the experiment to measure strain in individual fibres in a composite specimen. To the best knowledge of the authors, this is the first time that this has been achieved for a metal matrix composite. In addition we have gained valuable new information about the interface behaviour of fatigued Ti/SiC fibre composites at a high spatial resolution.

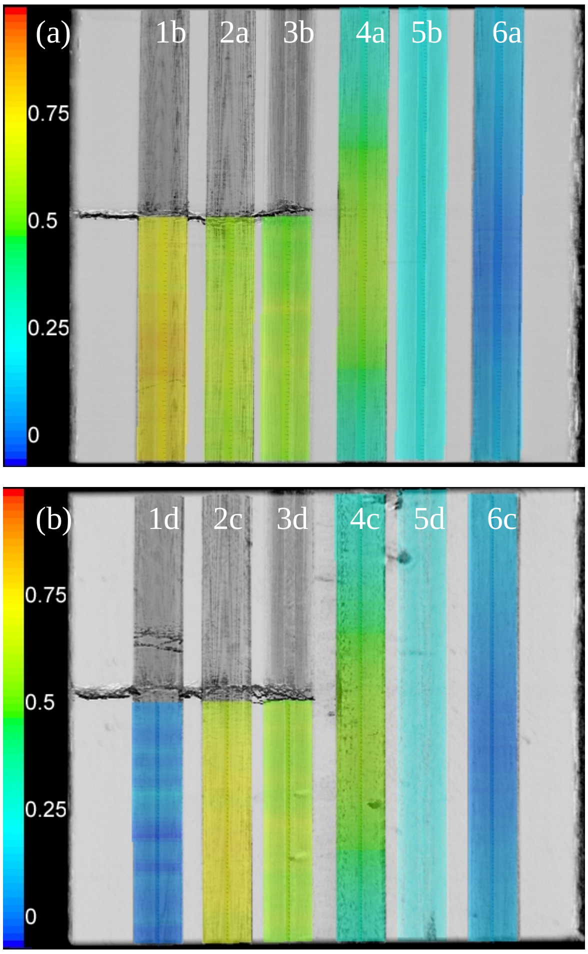

Figure 3. Fibre strain data superimposed on cropped tomographic sections showing fibres from each ply: (a) bridging fibre in ply 1; (b) broken fibre in ply 1. The strain (%) is indicated by the scale bar. Fibre 2c has higher strain than fibre 2a because fibre 1d is broken but fibre 1b is not.