ESRF	**Experiment title:** **Strain scanning – Engineering development of BM16 and ID11**	**Experiment number**: HS-674 (2)
Beamline: ID11	**Date of experiment**: from: 1998 II to: 1999 I	**Date of report**: 17 February 2000
Shifts: 30	**Local contact(s)**: A Kvick, G B M Vaughan, A Terry	*Received at ESRF:*

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Report:

ID11 Interim Report for the first year of a 2-year Long Term Project

Introduction: The proposal was for allocations of beamtime, over a period of two years, to enable the proposers and beamline staff jointly to develop techniques and equipment for medium to high energy, high resolution, strain scanning, and to make measurements on a series of test samples and components on the complementary instruments BM16 and ID11. This interim report outlines the work done on ID11.

ID11 was considered to be suitable for development as a higher energy (7-90 keV) high power strain scanner. Its location on an undulator source, together with its 2-D detector, provides the potential for very fast parallel data collection of full diffraction rings. Its higher energy range makes measurements through significant thicknessness of structural steel and nickel alloys to be practicable. However, its lack of collimation on the detector side made interpretation difficult because of the difficulty in separating angular and positional parameters. To become a practical strain scanner ID11 needed: (1) an automated XYZ translator and alignment system; (2) an annular detector-side slit system; (3) substantial software to process and analyse near-on-line the massive and rapidly accumulated data files, (5) substantial technique development.

Developments: ID11 now has provision for automated XYZ translation and standard mounting systems are to be incorporated. An annular slit system has been made and successfully tested and is now being further developed to provide longitudinal spatial definition. Considerable progress has been made on the software to provide polar re-binning of 2-D diffraction rings and near-real-time multiple peak fitting but substantially more development is required. Techniques are being developed to experimentally separate angular and position sensitive parameters, by translating the 2-D detector, as well as the sample, so that the potential of ID11 for very fast strain scanning can be realised.

Experiments: Several series of experiments have been undertaken as part of the individual and collective programmes of the three external proposers. Examples are given of high resolution strain scanning of composites and alloys, including in-situ loading experiments. References are given to these and other investigations [1-8].

SiC fibre reinforced titanium alloy materials were investigated on both ID11 and BM16. Different modes of loading were utilised, with particular focus on the material's response to local indentation. Strain maps were produced around the indentation made using a ceramic knife-edge, both during and following indentation. Indentations made both perpendicular and parallel to the fibre direction were studied in order to reveal the mechanism of load transfer between the matrix and the fibres characteristic of these situations. The combination of the local matrix plastic flow and fibre crushing in the vicinity of the indentation results in efficient stress redistribution, so that the medium-range strain map in the matrix strongly resembles that due to an elastic Hertzian contact. However, at larger distances along the fibre direction significant load transfer from the matrix occurs, and strain concentration is observed in the fibres in line with the indenter. Strains in Ti-SiC_f samples were also measured during bending following indentation [4].

ID11 and ID19 data have been used in combination to produce a picture of the evolution of damage and strain at 2 μm and 50 μm resolution respectively in a Ti-6Al-4V alloy reinforced with 140 μm diameter SiC fibres in collaboration with J-Y Buffrere and E Maire (Lyon). The build up of fibre stress within the bulk of a metal composite was measured for the first time. Axial and transverse strain data were collected simultaneously at a rate of 4 secs/point [3].

Residual strain maps in the vicinity of stress concentrators were collected in a series of Al alloy samples fatigued to different numbers of cycles. Significant variation of reflex-specific residual strains was observed, along with the variation of polar density (texture). In order to establish the diagnostic ability of multiple peak residual strain analysis for life prediction, further tests are needed on single specimens subjected to *in situ* cyclic loading [1].

The progress made on the project so far has established the basis for the use of synchrotron X-ray for engineering strain scanning. One of the recurrent topics was the significant benefit to be derived from a tighter integration between sample mounting, translation, and *in situ* loading arrangements.

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