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Report:

BM16 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 BM16.

BM16 was being used as a medium energy (7-40 keV) high resolution strain scanner. Its high angular resolution, together with the analyser in front of the detector, made it particularly suitable for studying light element materials and high-gradient strain fields at surfaces (as produced by peening) using selected Bragg reflections. However, the gauge defining slit systems required manual adjustment and they severely intruded into the sample space restricting measurements to small simple-shaped test samples in restricted orientations. It had a partially automated XY translator system but no controlled Z adjustment. To improve efficiency, accuracy and to become a practical strain scanner BM16 needed: (1) a robust XYZ automated translator, with provision for precise positioning of a wide range of different sized and shaped components and test samples; (2) automated and re-located precise slit systems to define the beams and 'gauge volume'; (3) fixed theodolites to define positions and to facilitate setting-up; (4) software for near-on-line data processing and analysis; (5) technique development.

Developments on BM16: BM16 has now been fitted with a new XYZ Schneeberger translator system providing 80×80×100 mm movement and a prototype standard VAMAS/RESTAND sample mounting system is being evaluated. Automated incident and detector slits have been installed and the sample environment area has been re-designed to accommodate the scanning of larger samples. Two theodolites are now employed for positioning and cameras are to be fitted to them to facilitate 'out of cabin' display. The software now enables Bragg peak parameters and strains to be calculated and to be displayed within minutes thus facilitating interactive experimentation. BM16 is now being regularly used by a number of expert groups to obtain high quality strain data. With modest additional development and further refinement it should soon be suitable for general use, as a high resolution strain scanner, by engineers without expert knowledge of synchrotrons.

Experiments: A wide range of experiments has been undertaken on lighter element aluminium and titanium based alloys and composites, particularly those of generic aerospace interest. Examples are given of high resolution strain scanning of light alloys, including through- and near-surface experiments. References are given to these and other investigations [1-11].

High resolution spatial scanning in aluminium alloy welds: Residual stress and distortion prevents the adoption of welding of most aluminium alloys by the aerospace industry. The high spatial resolution of BM16 enabled a residual strain map to be made around the end of a TIG weld (a point of stress concentration) in aluminium alloy plate. An area of 40×20 mm was scanned at 100 μm resolution in one shift which is almost as many measurements as have been made throughout the lifetime of the ISIS neutron strain scanner [7]. Comprehensive high resolution mapping was also performed on a friction stir weld [1,11] and a double-V weld [2,10] uniquely revealing detail that it is not possible to obtain at present by any other technique.

Laser shock peening is a relatively new surface treatment designed to produce a deeper compressive surface layer than is obtained by conventional shot-peening. Through- and near-surface scans were made of a laser shock peened Ti-6Al-4V plate, tapered to simulate the leading edge of an aero-engine fan blade. The resulting map revealed the residual stress field which was in good agreement with predictions.

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