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| **ESRF** | **Experiment title:**<br>FaME38 - Development of Materials Engineering at ESRF, Strain Scanning on ID11, ID15 and ID31 | **Experiment number**:<br>ME-543 |
| **Beamline**:<br>ID15B | **Date of experiment**:<br>from: 19/5/03 to: 21/5/03 | **Date of report**:<br>19/8/2003 |
| **Shifts:**<br>9 | **Local contact(s)**: Dr T Buslaps | *Received at ESRF:* |


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**Report:**

This interim report relates to the first part of an allocation of beamtime used to conduct a preliminary study of the potential of ID15Bfor strain scanning. A full report will be submitted once the main part of the beamtime has been used. This is scheduled for November 2003 and February 2004.

ID15 is the highest energy beam-line at the ESRF and as such is well-suited for development for hard X-ray strain scanning, particularly for studies in the very important denser engineering materials such as steels and nickel-based superalloys. ID15A has been used for some years, particularly by Reimers and Pyzalla [TU Berlin], for energy dispersive studies of thicker components and of denser materials and by Bastie et al for studies of high temperature nickel superalloys. ID15B is fitted with an innovative multiple spiral slit system and an area detector. This combination is very new and the instrument is at the start of its development phase. It has the very attractive potential, in principle, to determine the strain distribution from positions within a small elongated measuring volume in multiple directions from a single exposure. Point detector instruments, in contrast, determine the strain at a sample location in only one direction at a time. The ID15B spiral slit is 40 microns wide with a matching incident square cross-section beam. These, with the area detector, define a 'gauge volume' 40x40 microns square with a length of 20 mm. Consequently, for samples up to 20 mm thick, the full through-thickness signal from the gauge volume is recorded on the area detector. A variation in strain produces a small change in angle of the diffraction cone. Scattering from different regions of the gauge generate diffraction cones with different origins. On the detector the result is a series of curved lines that in principle can be de-convoluted to reveal the strain as a function of both position and orientation over the gauge volume.

In idealised fine-grained samples with large strain gradients this should be a very rapid and efficient way of mapping strain. However, the routine software that is required for analysing the ID15B data is yet to be written and the sensitivity of the instrument to grain-size effects, its applicability to near surface measurements, and its strain resolution capability are not yet established. The ID15B configuration may prove to be a revolutionary advance, or it may prove to be practicable for only a limited range of engineering problems and materials. The principal factors of concern are that the gauge cross-section is relatively small and cannot be easily increased and engineering materials are often relatively coarse-grained so very 'spotty' rather than smoothly averaged patterns can be produced. This, together with the detector pixel size will determine the future of the technique. Unfortunately, as the detector system is sensitive to the position of the sample, the opportunities for oscillating or vibrating the sample to improve the sampling statistics are very limited. At the present time the instrument is not yet ready for routine scheduling as a strain scanner but the software is scheduled to be developed during the summer of 2003 so that our May 2003 data may be analysed, and the concept evaluated, before our next allocation in November 2003.

To evaluate the potential of the instrument different shaped samples of a range of common engineering materials were studied. For the first time the combined use of the off-line FaME38 CMM, that is capable of measuring the shapes and locations of objects to within ±2 microns, and the VAMAS base-plate system, was employed. This facility, using a fine calibration pin in a VAMAS-compatible holder, initially enabled the position of the beam and gauge volume to accurately determined. Subsequently the shapes and positions of the different shaped samples were determined and positioned on ID15B to an accuracy of ±10 microns. Figure 1 is a representation of the VAMAS baseplate system with a sample attached in an L-shaped holder. The latter enables samples to be re-mounted rapidly, to ±10 micron positional accuracy, in orthogonal orientations at integral translations of 25 mm.

Figure 2 shows a section of a typical pattern from a machined aluminium alloy in which the relatively small size of the gauge volume results in a rather 'spotty' pattern because of the low number of grains sampled. The figure illustrates the factors that are likely to determine the resolution and potential of this new technique when applied to materials and components of real engineering significance. This will be quantitatively estimated for the range of materials investigated when the analysis software is available.

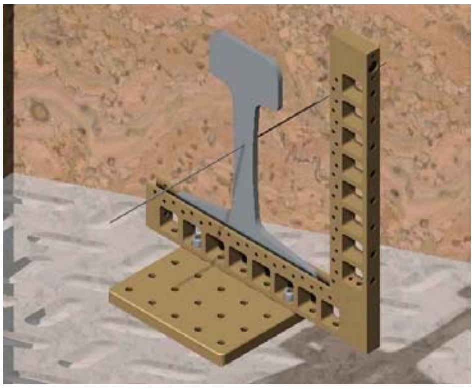

Figure 1. VAMAS base-plate system with L-shaped holder and illustrative (rail) sample

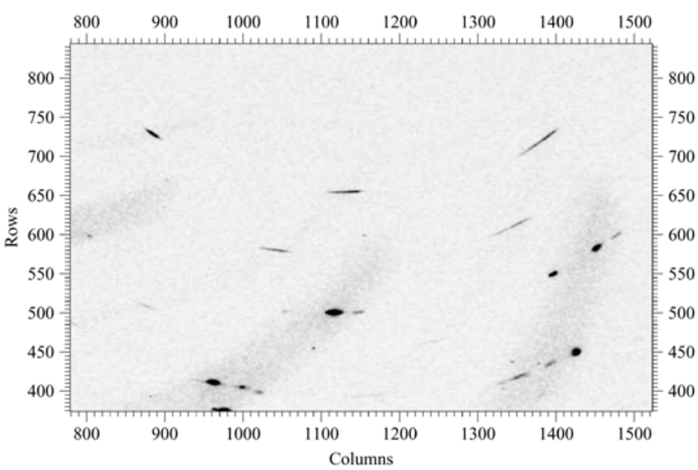


Figure 2 Enlarged section for a machined aluminium specimen showing poor grain sampling.