ESRF	**Experiment title: In-situ observation of stress and texture development during torsional deformation of aluminium samples**	**Experiment number**: ME-12
Beamline: ID11B	**Date of experiment**: from: 01-mai-00 to: 08-mai-00	**Date of report**: 16-august-00
Shifts: 18	**Local contact(s)**: MARTINS, René Valéry	*Received at ESRF:*

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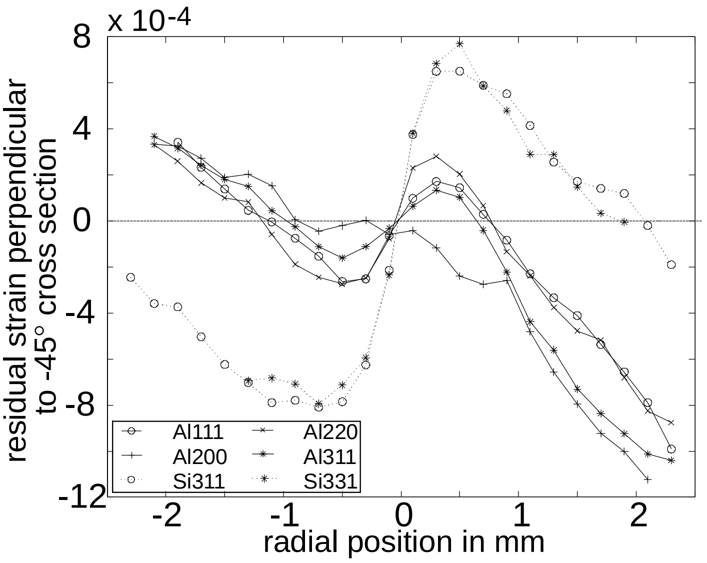
Report:

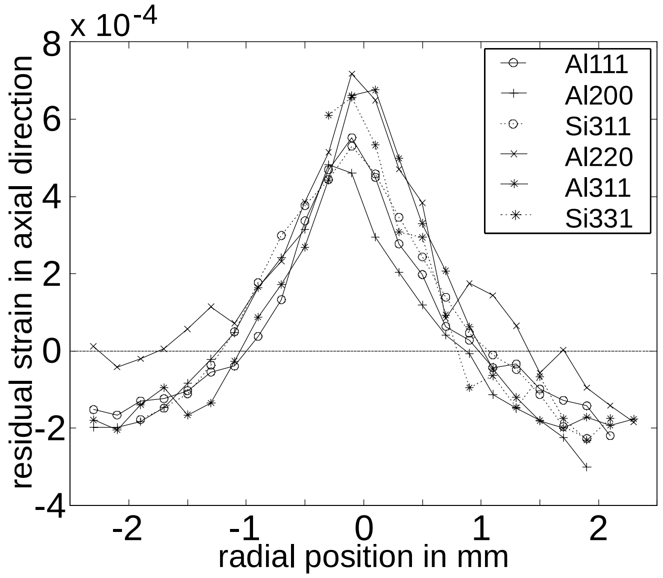
Along with tensile, bending, and simple shearing deformation, torsional deformation represents one of the basic deformation modes to obtain information about material properties. Large range deformation tests provide fundamental data for the development and verification of models for the plastic deformation, texture formation, and development of intergranular strains of crystalline solids. The torsional deformation of solid cylindrical specimens represents a simple method for obtaining a multiaxial deformation under well defined and easily reproducible conditions. The aim of the experiment was the investigation of the residual macro and micro strain for different crystallite groups and phases.
The size of the torsion samples made of AlMg3, AlSi25Cu4Mg1, and X10Cr13 was relatively small (diameter of the solid gauge section: 5mm) in order to reduce the dimensions of the torsion device which permits *in-situ* observations. The three-axial strain field in the torsion samples due to the plastic deformation is strongly dependent on the radial position of the gauge volume in the sample. Furthermore the orientation of the principal strain axes changes with the radial position.
In order to be able to resolve the steep strain gradients a high spatial resolution as well as high flux and penetration depth were required. Only the instrument on ID11B can meet these requirements due to its focussing optics which permitted an average spatial resolution of 10X10X300 μm^3 (HxWxL) at an energy of 80keV. The feasibility of the method was previously tested during in-house research /1,2/.
A low speed *in-situ* deformation in single direction was carried out at room temperature with free ends, i.e. the sample grips permit a longitudinal elongation/contraction of the sample during deformation. The texture development during the deformation integrating over the whole sample thickness was observed using a

2D-detector. After the deformation a 3D X-ray diffraction technique has been employed in order to investigate the radial dependence of the residual strain state in the deformed sample. This was achieved by means of a 2D focussed monochromatic beam (10x10µm, .15Å) and a triangulation slit. The reflections were monitored with a 2D detector. This technique permits a non-destructive investigation of the local strain with an average longitudinal resolution of 300µm depending on the reflection observed. The residual strain has been measured for different radial positions of the gauge volume and different ψ- and ω-angles. The local strain for up to six different reflections has been investigated. Steep residual strain gradients have been observed at the sample centre as expected (fig.1/2).



average error: ±5x10^{-5}

fig. 1: Residual strain profiles for different phases and crystallite groups perpendicular to -45° cross section of AlSi25Cu4Mg1 torsion sample cold deformed to γ=0.3



average error: ±5x10^{-5}

fig. 2: Residual strain profiles for different phases and crystallite groups in axial direction of AlSi25Cu4Mg1 torsion sample cold deformed to γ=0.3

The data obtained will permit the calculation of the complete stress tensor for different radial positions and different reflections. Furthermore large differences of around 4x10-4 in the strain state of the six different crystallite groups investigated have been observed which are caused by texture development and microstrain phenomena. The texture development during deformation shows a strong influence of the initial fibre textures, which are due to the manufacturing process of the raw material.

Due to the delivery delay of the conical slit system which was supposed to be used for this experiment, it was not possible to investigate the radial dependence of residual strain development during the deformation. The conical slit system is by now successfully commissioned and will be available for the next experiment scheduled for the end of september 2000.

/1/ MARTINS RV, KVICK Å, LIENERT U, POULSEN HF, PYZALLA A, *High energy strain scanning on highly plastically deformed torsion samples*, Proc. 20th Risø International Symposium on Materials Science, Roskilde, Denmark (1999) 411-416

/2/ MARTINS RV, GRIGULL S, LIENERT U, MARGULIES L, PYZALLA A, *Investigation of the Residual Strain State in Highly Plastically Deformed Al-MMC Torsion Samples Using High Energy Synchrotron Radiation*, Proc. ICRS-6, Vol 1,Oxford, United Kingdom (2000) 90-97