Experimental report

06/09/2022

Proposal: 1-02-289 **Council:** 10/2019

Title: In-situ determination of grain-orientation-dependent intergranular strain during defined uniaxial loading of duplex stainless steel

Research area: Materials

This proposal is a new proposal

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Samples: Steel rods - tensile sample X3CrNiMoN27-5-2

Instrument	Requested days	Allocated days	From	To
SALSA	4	4	08/07/2021	12/07/2021

Abstract:

For materials states exhibiting a strong texture the texture must be considered during data evaluation of diffraction residual stress (RS) analysis not least since often a large discrepancy between the measured and calculated strains can be observed in materials where the grain-orientation dependent RS is significant. These intergranular stresses (type II stresses) are caused by stress/strain incompatibility between grains having different orientations during mechanical deformation. Study of the grain orientation dependence of the RS not only enables an unmistakable assessment of the macro RS but also helps to answer fundamental questions such as how the grain-to-grain interactions during and after deformation proceeds. The grain orientation dependent strain or stress can excellently be monitored by determining strain pole figures. For a holistic assessment of the grain orientation dependent intergranular strain for duplex steel phase-specific lattice strain pole figures will be determined in-situ during mechanical loading. By this means we aim at developing a basic understanding of the micro-mechanical behavior, of the load partitioning behaviour and of the formation of micro RS.

Experimental Report – Proposal No. 1-02-289

In-situ determination of grain-orientation-dependent intergranular strain during defined uniaxial loading of duplex stainless steel

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Abstract/Aim

For materials states exhibiting a strong crystallographic texture the preferred orientation must be considered for data evaluation of diffraction residual stress (RS) analysis not least since often a large discrepancy between the measured and calculated strains can be observed in materials where the grain-orientation dependent RS is significant. These intergranular stresses (type II stresses) are caused by stress/strain incompatibility between grains having different orientations during mechanical deformation. Study of the grain orientation dependence of the RS not only enables an unmistakable assessment of the macro RS but also helps to answer fundamental questions such as how the grain-to-grain interactions during and after deformation proceeds. The grain orientation dependent strain or stress can excellently be monitored by determining strain pole figures. For a holistic assessment of the grain orientation dependent intergranular strain for duplex steel, phase-specific lattice strain pole figures should be determined in-situ during mechanical loading. By this means, the development of a basic understanding of the micro-mechanical behavior, of the load partitioning behaviour and of the formation of micro RS can be provided.

Measurement setup:

In this first approach, we focused on the investigation of the duplex steel type, X2CrNiMoN22-5-3 (1.4462). This steel provides a phase composition of about 50% ferrite and 50% austenite in the as received state. In-situ tensile loading experiments were carried out using dog-bone shaped tensile samples with a diameter of 4 mm in the measuring length. The phase-specific strain distributions were determined for 0, 1, 4 and 10% total strain. The experimental procedure is shown schematically in Figure 1. A nominal gauge volume of 2 x 2 x 2 mm³ was used, which was defined by radial collimators at the primary and secondary beam paths. In this way, quarter pole figures were determined by measuring diffraction lines for different orientations of the scattering vector (Φ and ξ angle was varied) with a step size of $\Delta\Phi = 7.5°$ and $\Delta\xi = 5°$ in for different {hkl} lattice planes for the austenite and the ferrite phase using a neutron wavelength of 1.645 Å.

Preliminary results

Based on the measurement results, complete texture information and strain pole figures should be calculated from the measured quarter "pole figures". An example of such re-calculated strain pole figures can be seen in Figure 2. Based on the first evaluations, it can already be concluded that there is only small development of I phase-specific texture.

However, we observed a strong development in the strain pole figures as can be seen in Fig. 2.

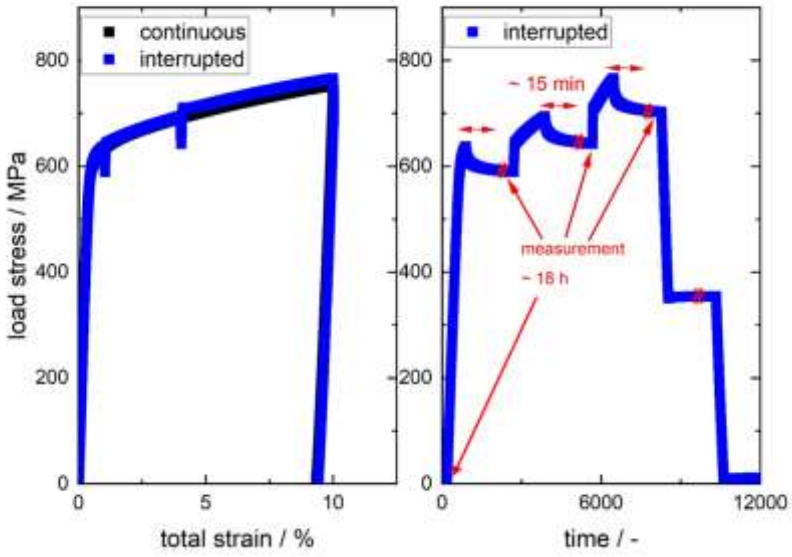

Figure 1: measurement positions

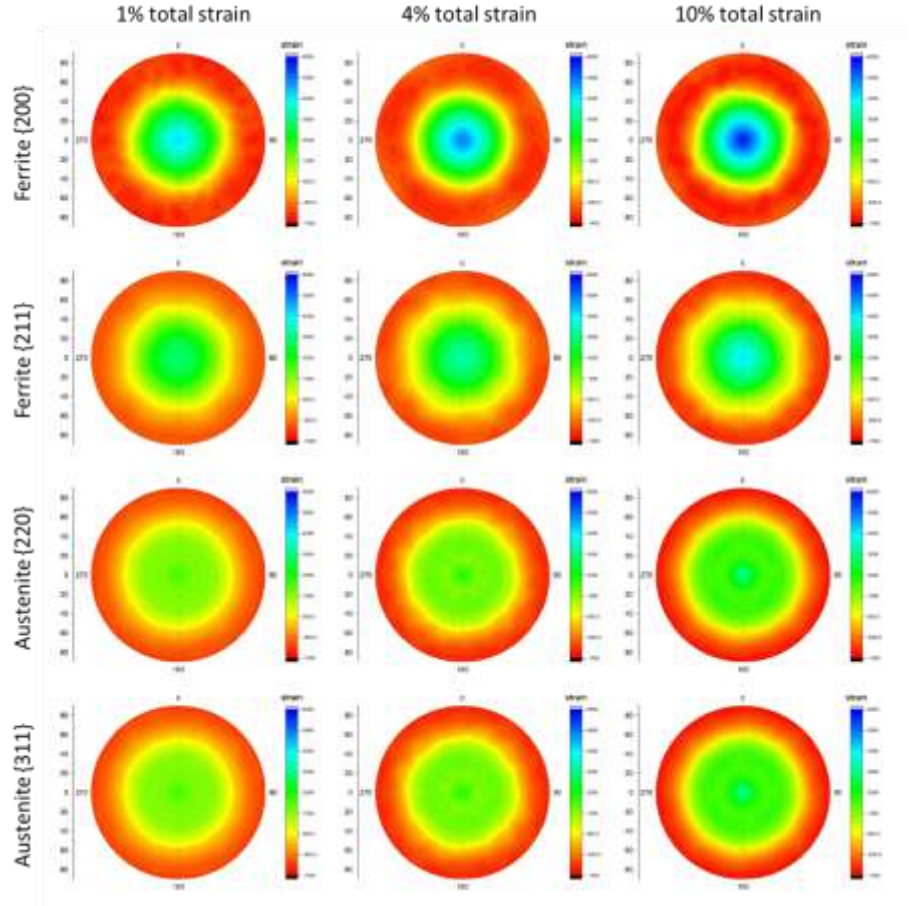

Figure 2: Calculated strain pole figures for the 3 measured load levels (preliminary results).

Currently, the data is being finally evaluated. Together with the results of the accompanying investigations (e.g. lab XRD analyses), the results are prepared for publication in renowned journals. Furthermore, the results will we inserted and discussed in the PhD thesis of Samuel Pulvermacher.

We would like to thank the ILL for granting the experiment and the staff for their excellent and helpful support, which guaranteed the successful beamtime.