EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

ESRF

# Experiment Report Form

**The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF**.

Once completed, the report should be submitted electronically to the User Office using the **Electronic Report Submission Application:**

*http://193.49.43.2:8080/smis/servlet/UserUtils?start*

***Reports supporting requests for additional beam time***

Reports can now be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

***Reports on experiments relating to long term projects***

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

***Published papers***

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

## Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

## Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

| ESRF | **Experiment title: Observation of the stress-induced martensitic transformation in TRIP-steel** | **Experiment number**: ME178 |
|---|---|---|
| **Beamline**: ID 11 | **Date of experiment**: from: 23 june 2001 to: 27 june 2001 | **Date of report**: |
| **Shifts:** 11 | **Local contact(s)**: S. Grigull and L. Margulies | *Received at ESRF:* |


**Names and affiliations of applicants** (* indicates experimentalists):

Dr. ir. Jilt Sietsma*1, Dr. Lie Zhao*2 and Ir. Suzelotte Kruijver*2

[1]Delft University of Technology, Laboratory of Materials Science, Rotterdamseweg 137, 2628 AL Delft, The Netherlands

[2]Netherlands Institute for Metals Research, Rotterdamseweg 137, 2628 AL Delft, The Netherlands


## Report:

The steel under investigation is of interest because its formability is increased by the so-called transformation-induced plasticity (TRIP) effect. The enhanced plasticity is due to a martensitic transformation of retained austenite (FCC, up to 10 vol.% [1]) into a slightly tetragonal ferrite (BCC) when a mechanical stress is applied. The critical stress needed to induce the transformation is expected to depend on the carbon content of the austenite and the dimensions of the grain. The aim of the research is to establish these relations. They have so far not been determined, and are of great importance for both the understanding of the TRIP-effect and the effectiveness of the thermomechanical treatments applied to produce TRIP-steels.

The 3D X-ray Diffraction microscope at beamline ID11 of the European Synchrotron Radiation Facility equipped with a stress-rig gives the opportunity to follow the development of individual grains. During this investigation diffraction patterns are taken while increasing the strain level step-wise up to 12 %. The stability of the retained austenite is studied as a function of the orientation of the grains and the stress level. Moreover, the development of the carbon concentration of the remaining austenite is investigated.

In the present analysis the individual austenite spots are not distinguished, but the diffraction patterns are treated like powder patterns. Results of the preliminary analysis of {200} reflections are shown in figure 1, 2, and 3. The angle $\eta$ denotes the angle between the tensile direction and the normal direction of the diffracting plane.

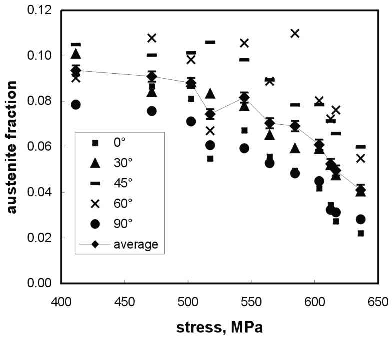


Figure 1: Austenite fraction versus stress for different η-angles.

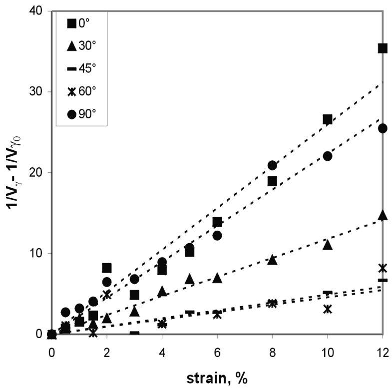


Figure 2: Ludwigson and Burger relation is used to show the influence of the orientation on the stability of the retained austenite for different η-angles.

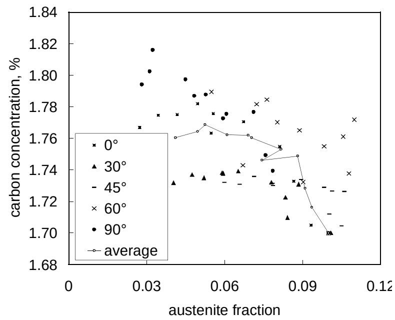


Figure 3: Carbon concentration versus the retained austenite fraction for different η-angles.

Figures 1 and 2 both show that grains with η = 0° and η = 90° are the least stable grains. A maximum stability is found for grains with η = 45° or η = 60°.

It is possible to determine the change in carbon concentration in austenite as a function of the remaining retained austenite. The limited increase in the average carbon content with decreasing austenite fraction indicates a relatively narrow distribution of carbon concentration.

Further analysis work will be done to improve and to expand the results. Future plans for the data analysis are analysis of the full diffraction rings, other austenite reflections and the data of the second tested sample. Other options, which are of interest, are single grain analysis of the 0% strain state diffraction patterns and the texture development of austenite and ferrite during straining. The analysis is done in collaboration with the Materials Research Department of Risø National Laboratory.

Single grain analysis at higher strain levels is not possible with the data of this experiment. Even at the initial state the austenite spots are fairly wide both in θ- and ω-angles. This most likely implies that the austenite still bears traces of the rolling deformation of the material before the heat treatment. By choosing a material with a slightly different composition it will be possible to fully recover the material before given the actual heat treatment to form the TRIP steel.

Submitted paper

Kruijver S.O., L. Zhao, J. Sietsma , S.E Offerman., N.H. Van Dijk, L. Margulies, E.M. Lauridsen, S. Grigull, H.F. Poulsen, S. Van der Zwaag, *In situ observations on the austenite stability in TRIP-steel during tensile testing*, International Conference on TRIP-Aided High Strength Ferrous Alloys, June 2002, Gent

Reference

[1] Zhao L., N.H. van Dijk, E. Brück, J. Sietsma, S. van der Zwaag, *Magnetic and X-ray diffraction measurements for the determination of retained austenite in TRIP steels*, 2001, Mat. Sci. and Eng. A, 313 (1-2): 145-152