ESRF	**Experiment title:** Scanning XRD Investigations of strain-induced Martensite Distribution in fatigued austenitic steel 321	**Experiment number**: ME395
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Names and affiliations of applicants (* indicates experimentalists):

Mirco Grosse*, Markus Niffenegger*

Paul Scherrer Institut Villigen, Switzerland

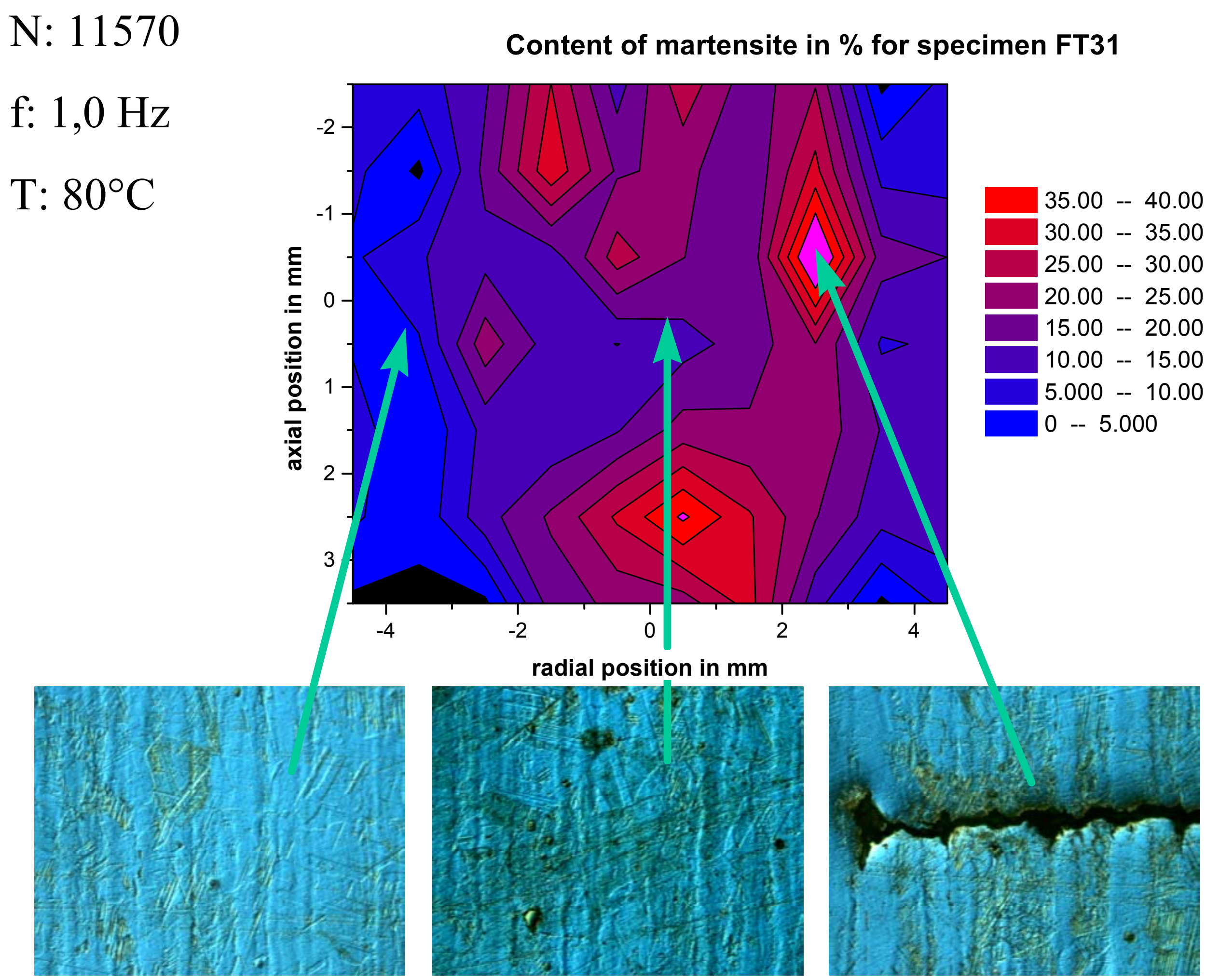
Report:

Cyclic strains lead to material degradation known as fatigue damage. In some meta-stable austenitic steels mechanical load is accompanied by strain-induced martensitic transformation [1]. The ferromagnetic martensite phase can be detected by non-destructive measurements of magnetic and electric properties of the material. The different testing methods like susceptibility measurements or the determination of the eddy current impedance have different penetration depths. In order to discuss the differences in their results the distribution of martensite in the sample has to be known.

In the performed experiments the martensite distribution at cross sections of 16 fatigued samples differ in their chemical composition and in the applied fatigue test conditions, were investigated. With a beam cross section of 0.4 mm * 0.8 mm and a wave length of 0.1787 nm a gauge cross section of about 0.8 mm * 0.8 mm was realised. The sample cross section was scanned with 1 mm steps in both directions. The texture is known from former neutron diffraction experiments, therefore the martensitic content was estimated from the relation between (111) austenite and (110) martensite peak intensity [2].

The intensity of the (111) austenite peak shows a strong dependency on the lateral sample position. Reason for this dependency is not only a different phase composition but also the bad grain statistics caused relative large austenite grains compared with the gauge cross section. In contrast to the austenite, the grain size of martensite is small enough and the number of martensite needles high enough for a good grain statistic. Therefore the (111) austenite intensity averaged over the whole cross section was used for the estimation of the martensite content.

As an example of the results the determined martensite distribution is compared with typical metallographic images of surface, bulk and crack regions of sample FT31 (strain amplitude: 0.4 %, load cycle number: 11570, test frequency: 1.0 Hz, test temperature 80°C). In the metallographic images using polarised light the austenite has a blue colour whereas the martensite is yellow-green.



The quantitative results of the scanning XRD experiments are in good agreement with the metallographic images. In each sample where strain-induced phase transformation occurred the martensite is concentrated in the bulk (middle of radial direction) wear as the concentration of martensite close to the surface is significantly lower. Also in axial direction the martensite content varies, but, -as expected-, not systematically. At crack positions the highest martensite contents were found. At these positions stress and strain concentrations occurred during the fatigue test which results in an stronger strain-induced phase transformation. Different chemical compositions, strain amplitudes and fatigue test temperatures might influence the total content of martensite but not the general martensite distribution in the sample.

The measured lateral distribution of martensite is essential for a better understanding of the results from different applied non-destructive testing methods. Since susceptibility measurements provide information from the bulk (penetration depth about 10 mm) this method is better suitable to detect the material state than eddy current measurements with typical penetration depths of 0.1 .. 1.0 mm.

References

[1] M. Grosse, M. Niffenegger, D. Kalkhof: J.Nucl.Mater 296 (2001), 305

[2] G.Fanninger, U.Hartmann: HTM 27 (1972), 233