ESRF	**Experiment title:**	**Experiment number:** HS 1017
Beamline: BM 16	**Date of experiment:** from: 06.10.99 to: 13.10.99	**Date of report:** 29.02.00
Shifts: 9	**Local contact(s):** Ian Pape, Andy Fitch	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

O. van der Heiden, A. Pyzalla*, S. Dieter*, T.Poeste*

Hahn-Meitner-Institut
Strukturforschung, Werkstoffe SF3
Glienicker Strasse 100
D-14109 Berlin

Germany

Report:

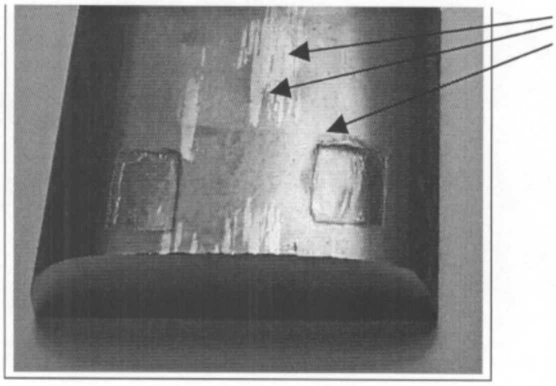
The increase of axle loads in freight traffic as well as the increase in speed of passenger trains within recent years have lead to an increase of wear of the rails, that appears e.g. in an increase of frequency of structure modifications and defects in the rails' surface layer. Among the structure modifications are riffle bands and the so-called white-etching-layers. These areas have been the subject of a number of investigations since not only the formation of these layers is liable to cause failure of the rail surface but also since from the results of the investigations a better understanding of the microstructural processes of friction and wear is sought for.

The white etching layers have been named according to their resistance towards metallographic etching. They have been shown to reach hardness values up to 1200 HV. The composition and crystallographic structure of the white etching layers as well as the process of their formation still is a subject of controversy. This partially is due to the fact that white etching layers have been reported to appear with a ferritic microstructure in components subjected to high mechanical loading where the occurrence of temperatures enabling austenitisation are unlikely.

But, white etching layers also were found with a martensitic structure formed due to a combination of strong plastic deformation and peak temperatures allowing for re-austenitisation and martensitic transformation due to cooling and plastic deformation.

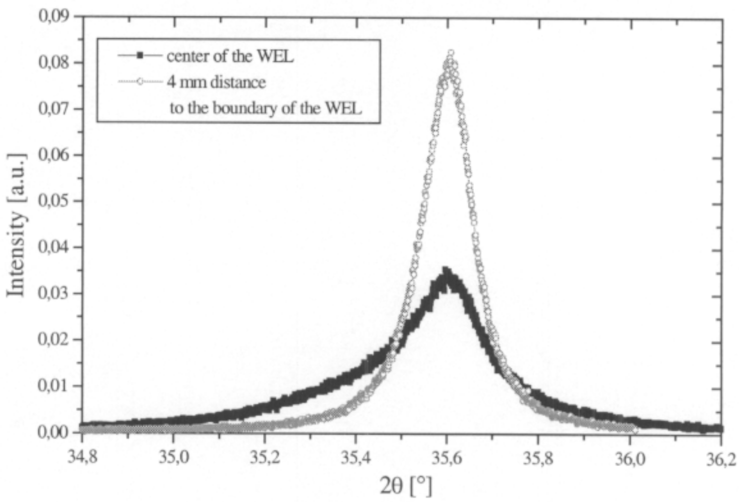
Here a severely corrugated rail was investigated that showed elliptical patches of white etching zones on the surface.

Fig. 1: View on top of the rail



The white etching zone is clearly visible. It extends to a maximum depth of 100 µm. With instrumented indentation tests values about twice as high as usually found for pearlitic steel were measured at the BAM, Berlin. TEM investigation revealed a martensitic microstructure, though the prior austenite grain size was much smaller as usually observed for thermally produced martensite in steels. The martensitic structure of these WELs, too, could be proven by X-ray and synchrotron X-ray diffraction as shown in Fig. 2. Whereas the profile is braodened but symmetric in the worn regions adjoining the WELs, in all WELs investigated asymmetric line profiles of the reflections were found. The asymmetric profile is especially pronounced for the (200)-line (fig.2).

Fig.2:
Profile of the 200 reflection in the WEL and the adjoining material



Within all WELs investigated martensite was detected, in none of them retained austenite was found. The results of the experiments revealed that in the regions adjoining the white etching layer a ferritic matrix is present which has a high dislocation density. With increasing distance to the WEL the dislocation density decreases with a steep gradient. This effect was reproducible for several the region around several WEL.