ESRF	**Experiment title:** Martensite Formation of Micro- and Nanocrystalline Ferrite – Pearlite Microstructures at High Pressures and Elevated Temperatures	**Experiment number**: 15
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1. Introduction

Severe friction and wear e.g. of tools and rails leads to the formation of so-called white etching layers [1]. White etching layers are named as a consequence of their resistance toward metallographic etching and, thus, their featureless appearance under optical microscopes [2]. They reach hardness values up to 1200 HV [3, 4]. The composition and the structure of the white etching layers as well as their origin still are under vivid discussion [e.g. 1 - 6], since the white etching layers are detrimental to the lifetime of rails. This is due to crack formation in the brittle white etching layers, which leads to severe rail corrugation. Among the theories for the formation of white etching layers the role of temperature, deformation, environment, strain rate, pressure and cooling rate essentially are agreed upon [5, 7]. Within previous investigations we could prove for the first time by using X-ray imaging methods that the white etching layers on railway rails contain martensite and retained austenite. Reflection profile analyses showed that the martensite is nanocrystalline [8]. Since on the rail surface the loading is inhomogeneous different stages of the microstructure alterations which finally lead to the formation of the white etching layer are present [9,10]. Thus, we could develop a model (fig. 1) for the microstructure development. We proposed that the cementite lamellae in the pearlite break due to the heavy loading.

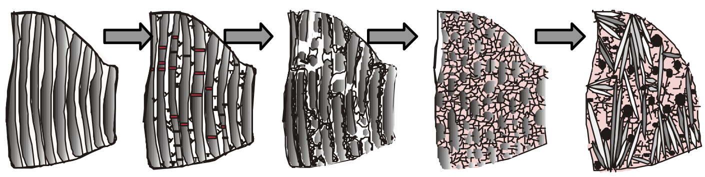

Fig. 1: Model describing the formation of white etching layer on rails

Although it now has been proven beyond doubt that the white etching layers on rails are martensitic the problem remains how austenitisation takes place. FEM calculations performed e.g. by [11,12] indicated that the temperatures reached in contact between rail and wheel are 500°C at maximum. Thus, under ambient pressure they are not sufficient to reach the austenite phase. But, calculations also show that due to the heavy loading contact pressures of about 1 GPa [11] res. 1.9 GPa [12] are reached. This value, however, depends on the real contact geometry, which following the concept of asperity contact might be considerably smaller. Therefore it is expected that the high contact pressure and the specific microstructure containing very fine cementite lamellae causes the surface of the rail to reach the austenite temperature. While phase diagrams are available for iron-cementite even at very high pressure, so far the influence of the microstructure morphology (cementite shape and size) has not been considered so far.

2. Experiment and Results

Experiments were performed on 8 samples including 5 different steels. The samples were loaded by different pressures and temperatures in a Paris-Edingburgh-cell. Micrographs of the samples after the deformation process have been prepared, an example is shown in figs. 2, 3.

Fig.:1 Image of sample after the experiment

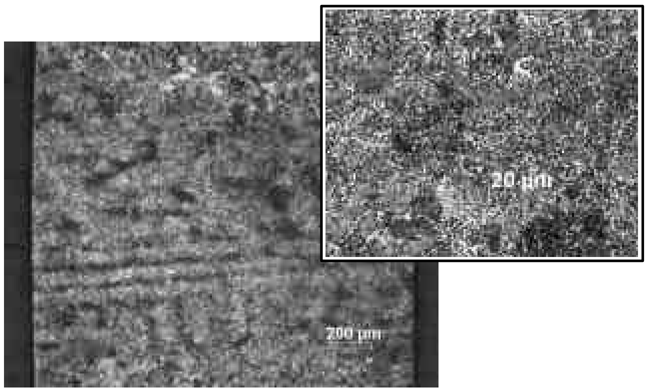

Fig.: 2: Microstructure of a deformed sample

A typical diffractogram obtained is shown in fig. 3. Here, the austenitisation temperature was not yet reached. The detail shown in fig. 4 reveals the reflections of the carbides Fe_3C and $M_{23}C_6$. A closer inspection of these reflections shows that a decrease in their intensity and a change in their profile (towards smaller fwhm) is visible for higher pressures. A detailed investigation of the diffractograms is in progress.

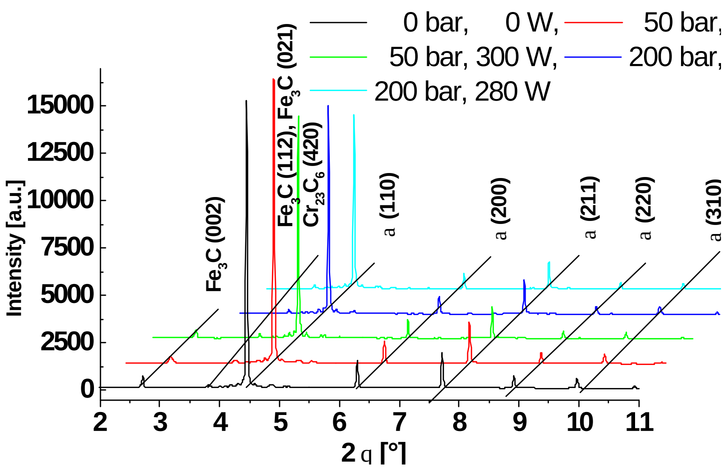

Fig: Diffractograms obtained for FeCrC

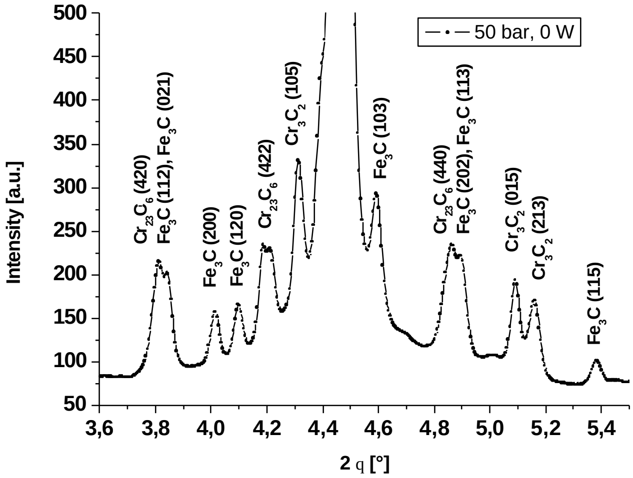

Fig. Detail of a diffractorgram, FeCrC

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