ESRF	**Experiment title:** **Intergranular and interphase stress studies of creep-resistant steels**	**Experiment number**: MA-994
Beamline: ID11	**Date of experiment**: from: 23/04/2010 to: 26/04/2010	**Date of report**: 14.09.2010
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Report:

One principal goal was to study the behaviour of the ferrite matrix and the second phase cementite during deformation at 565° in a creep resistant 1CrMoV bainitic steel. Previous measurements using neutron and synchrotron XRD at the facilities at the Paul-Scherrer Institut, Switzerland have been performed. Ex situ neutron diffraction showed that residual compression strain develops in the ferrite matrix after tensile deformation at room temperature. In situ tensile testing at room temperature (RT) using synchrotron XRD revealed large tensile residual stresses in a low volume fraction second phase cementite that hence acts as a reinforcing phase. However, ex-situ neutron diffraction on creep deformed (565°C, 270MPa) samples do not show a build-up of ferrite phase strains although intergranular ferrite strain are present in the matrix. It hence appears that the second phase cementite is no longer strengthening the matrix during creep in the same way as it does during tensile loading at RT. In situ tensile loading at RT and 565° have been performed at ID11 to investigate whether the high temperature or the different type of loading causes this discrepancy. The current status of the data analysis is reported in the following. Figure 1 shows the set-up with the ETMT at ID11. Our group has modified and improved the set-up using custom made grips to avoid sample slipping during testing. A SmartCamera had been installed to determine the actual strain in the gauge section of the sample using an image correlation technique. Also the ETMT steering program has been improved, e.g. visualizing of the stress-strain curve during

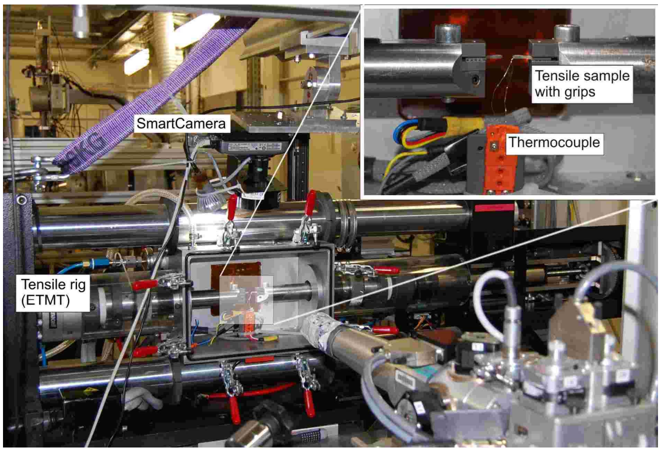

Figure 1 Set-up of the ETMT at ID11

loading. The stress-strain curves recorded during in-situ loading are shown in Figure 2 for both room temperature and 565°C. Diffraction rings from both the ferrite matrix and the second phase cementite were recorded on the Frelon2k detector. In order to increase the angular resolution only a quarter of the diffraction ring was recorded (Figure 3). These images have been integrated for an azimuthally degree range of ±1, ±3 and ±7 in both axial and transverse direction. The lattice strain was then been determined. Figure 4 shows the evolution of the lattice strain as a function of the applied stress for three ferrite grain families during loading at RT. We do find a discrepancy to the expected behaviour that can be summarized: a) different slopes for the ±1, ±3 and ±7 degree azimuthally integration, b) ratio of axial and transverse direction (should be poison ratio, e.g. close to 0.3), c) not linear increase in lattice strain in the steel elastic regime and to summarise, d) the discrepancy between this data and a similar dataset previously obtained at PSI using neutron diffraction. We are currently in close contact with the beamline staff to indentify and resolve the mentioned discrepancies. The experiment itself did run well and also the mechanical data is fine. Therefore the mentioned discrepancy is supposed to be diffraction related (probably calibration /detector setting). We think we can solve identify the problem and wish to repeat some measurements somewhere in the future. Because the issues with the RT data are not resolved, the high temperature data processing and the foreseen modelling using an elasto-plastic self-consistent scheme cannot be advanced.

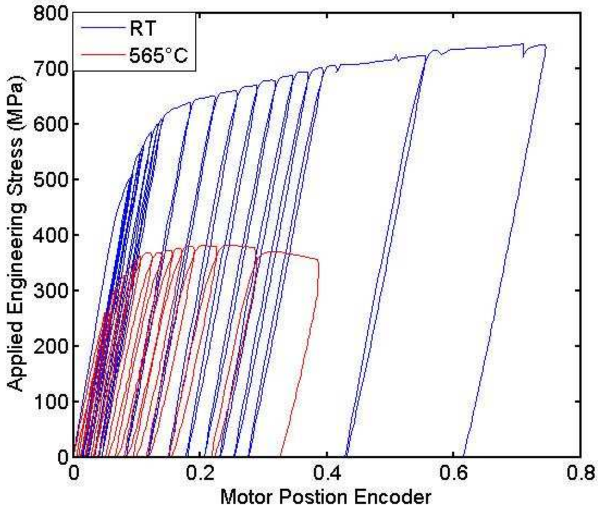

Figure 2 Figure 2 Stress-strain curve for the 1CrMoV creep resistant bainitic steel recorded during in-situ tensile loading at RT and 565°C. Here with load/unlod cycles.

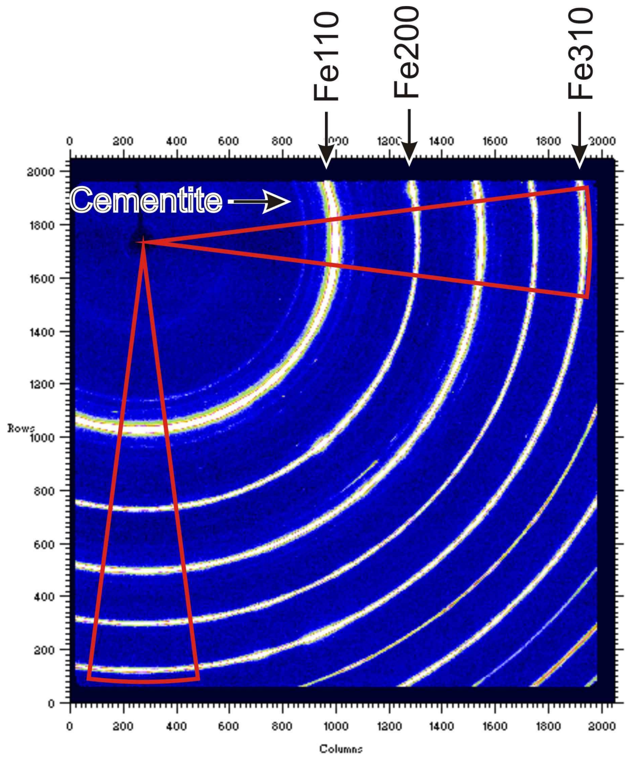

Figure 3 2D diffraction pattern showing the ferrite matrix peak and low intense peaks from the second phase cementite. The data has been integrated aizmuthally,as indicated by the red arcs in both directions parallel and perpendicular to the tensile axis.

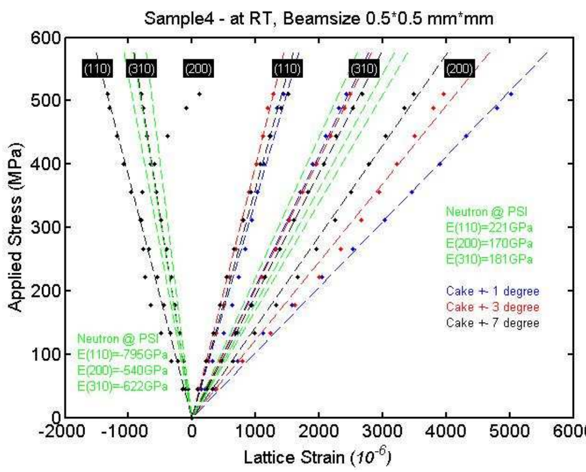

Figure 4 Lattice strain as a function of applied stress for three ferrite grain families. The different colours indicate the result for different azimuthally integration ranges. The green lines indicate the corresponding lattice strain evolution measured during in-situ neutron diffraction at POLDI (PSI) and can be taken as a reference.