Experiment title: **Nanobainitic steels : phase transformation mechanisms and stability of retained austenite**		Experiment **number: MA 2305**
Beamline: **ID15b**	**Date of experiment:** **from: 11/12/2014-17/12/2014**	**Date of report:** **13/04/2015**
Shifts: **12**	**Local contact(s):** *Thomas Buslaps*	**Received at ESRF:**
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report

A new generation of steels relies on bainitic microstructure formed at an abnormally low temperature (150-300°C) that contains nano-scale (20–60 nm) plates of ferrite and a significant volume fraction of retained austenite, between 15-40% depending on the transformation temperature and time. The project aims at investigating the origin of the mechanical stability of retained austenite in these nanobainitic steels which are developed for their ultra-high strength (above 2 GPa), their superior ductility and high toughness.

The proposed experiments consist in (i) in situ studies of bainitic transformations in extreme conditions (low temperature during few hours) and (ii) in instrumented tensile tests. During phase transformation and mechanical tests, the phase fraction and lattice parameters of the phases are followed thanks 2D diffraction patterns (powder diffraction configuration). The experiments have been carried out on ID15B (90keV) line with a 2D fast detector in the ETMT Instron device, to capture rapid phenomenon occurring during displacive phase transformations.

Two different bainitic grades have been studied:

- a nano-structured bainitic steel (ICSI) with the composition Fe-1C-2.5Si-0.75Mn-1Cr (wt.%) transformed at 220°C for 22h and at 250°C for 16h,
- a more conventional bainitic steel (BT21) with a sub-micron microstructure with the composition Fe-0.3C-1.5Si-2Mn-0.4Cr (wt.%) transformed at 425°C for 30 min and at 450°C for 30 min for the sake of comparison.

In situ tensile tests

The tensile tests under radiations have been performed in quasi-static conditions at room temperature. Specific jaws have been machined for the experiments thanks to the support of the line engineer.

9 tensile tests (cf. Figure 1) have been realized but only 4 experiments can be exploited (1 for each condition). It appears that all the tensile curves (displacement of the jaw vs. load – no

possibility to use an extensometer) show a kind of plateau (cf. Figure 2). At the first sight, we have interpreted it as a Lüders' plateau but all the steels seem to present the phenomenon.
We are now quite convinced that it was an artifact related to the ETMT. During the last trials, we have used additional wedges to prevent sample from sliding without any improvements.

The RX diffractograms will now be checked in order to remove these artifacts from the tensile curves. We will also perform additional tensile tests on the remaining samples to measure convincing tensile curves and uncorrelate the phenomena.

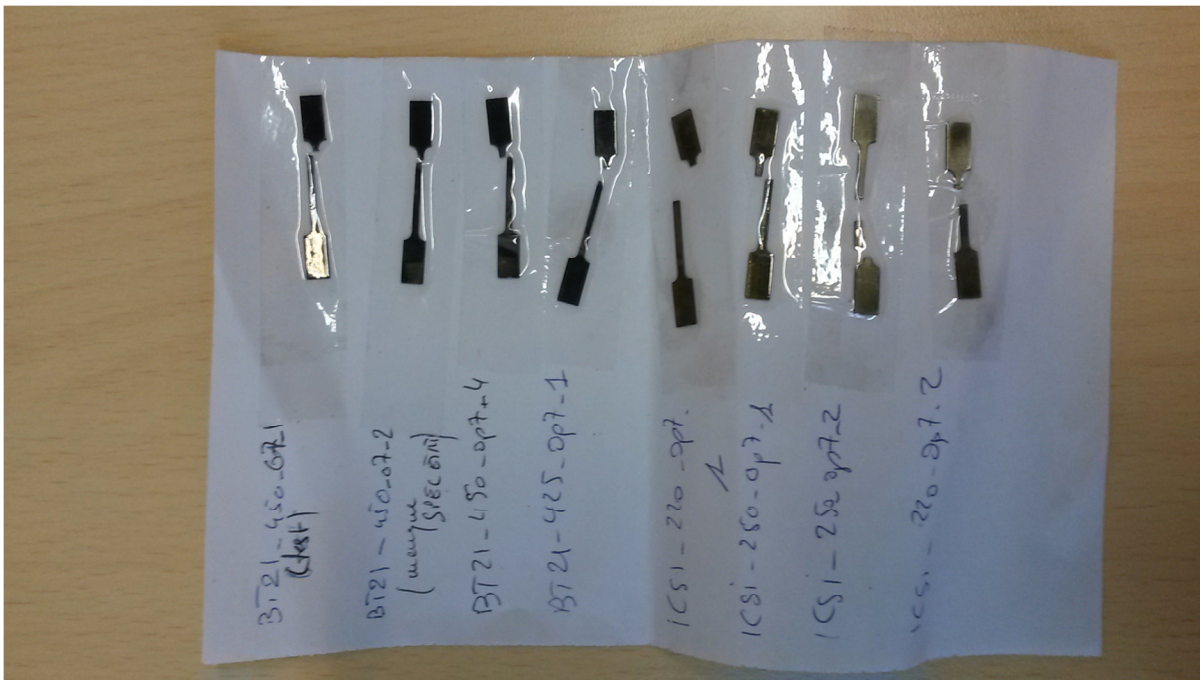

Figure 1: Broken tensile specimens after in situ tensile tests

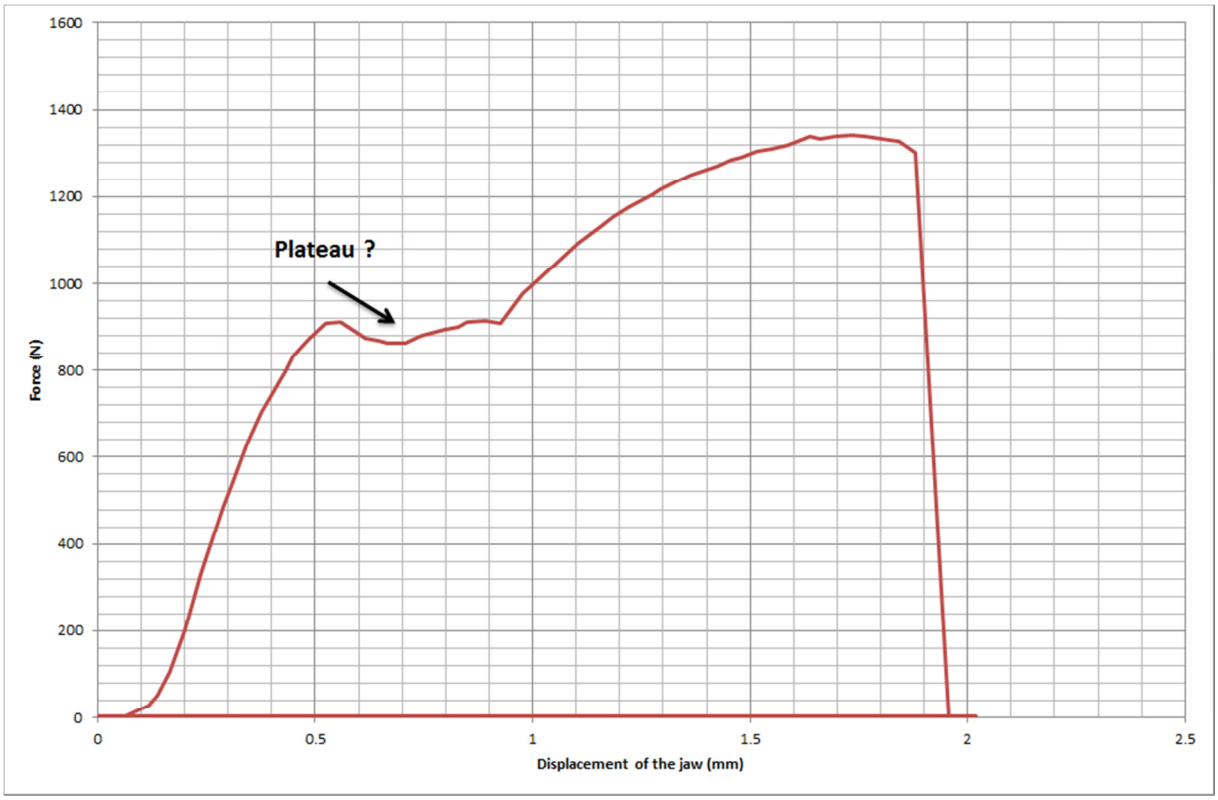

Figure 2: Typical tensile test (BT21_450 sample) – Force vs. displacement.

In situ bainitic transformations

5 trials have been launched but only 3 can be exploited.

- 1 BT21 sample transformed at 425°C during 1h30
- 1 ICSI sample transformed at 250°C during 16h
- 1 ICSI sample transformed at 220°C during 16h (cf. Figure 3)

During all the trials, the measurements of the temperature with the ETMT (thermocouple welded on the sample) have been considered as critical. To address this issue, an additional pyrometer has been installed to control the value given by the ETMT (no records however). The quality of the spot weld as well as the orientation of the electric wires could lead to difference between the measures higher than 100°C. Trials have been considered as acceptable when the difference between values given by the thermocouple and the pyrometer is limited to about 30°C.

For the long experiments, the recording frequencies have been adjusted to minimize the datasets.

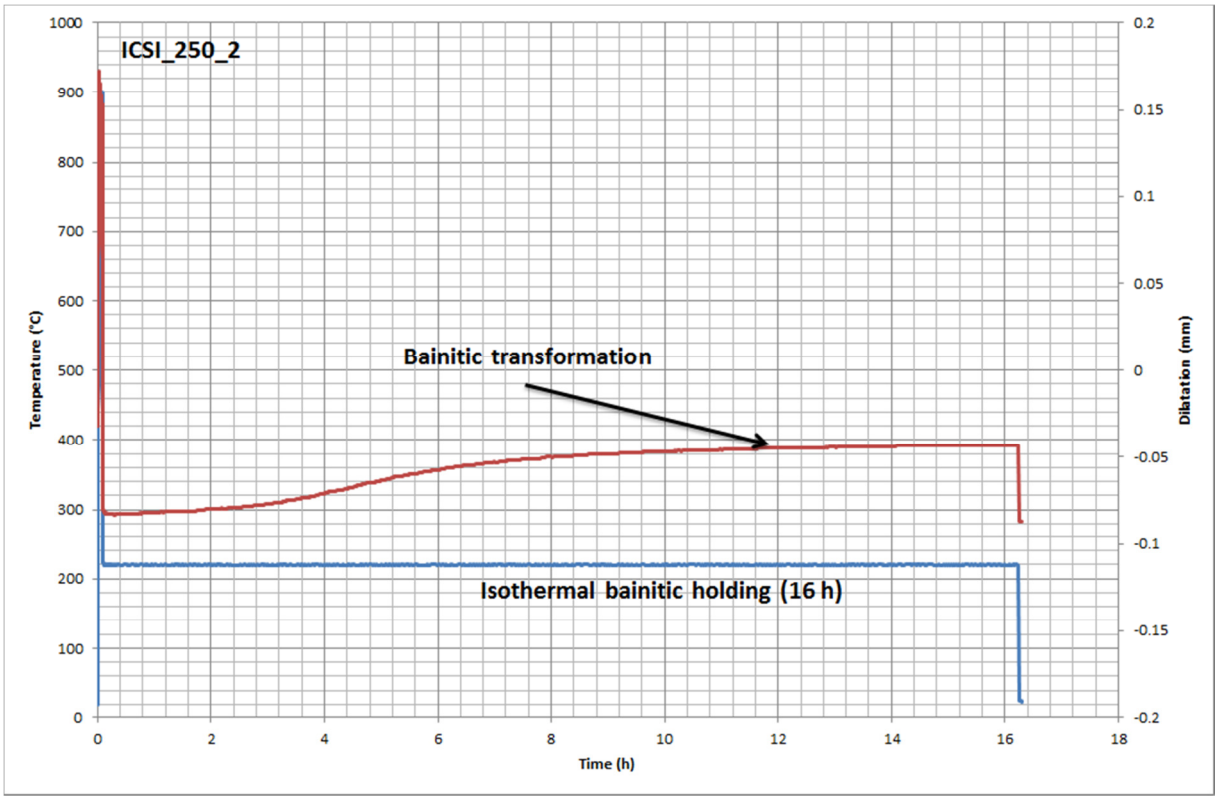

Figure 3: Typical thermal cycles performed on ICSI samples (transformation at low temperature – 220°C during 16h). The displacement of the mobile jaw has permitted to record the global dilatation of the samples which seems to reflect rather well to the bainitic transformation kinetics (“dilatometer” like signal).